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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C. 2

VOL. CIII.—No. 2677.] *LONDON: FRIDAY, APRIL 20, 1917.* [Registered at the General Post Office as a Newspaper.] PRICE 9d. By Inland Post 10d.

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IN THE MATTER OF THE TRADING WITH THE ENEMY AMENDMENT ACT, 1916.

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The issued capital of the Company consists of 120,000 Shares of £5 each, fully paid.

The purchasers, who must be British-born subjects, will be required to make a sworn Declaration as to nationality and freedom from foreign control on a form to be obtained from the Offices of the Public Trustee.

The purchasers will also be required to satisfy the Public Trustee as to their financial and technical ability to carry on the business of the Company as efficiently as heretofore, or otherwise to the satisfaction of the Government.

A report upon the Company's operations and affairs has been prepared by the Company, in conjunction with the Company's Auditors (Messrs. PRICE, WATERHOUSE & Co.), and with Messrs. TURQUAND, YOUNGS & Co. Copies of this report can be obtained, subject as hereinafter mentioned, together with copies of Company's accounts up to the 31st December, 1916, on written application to the Public Trustee, Kingsway, W.C.

All applicants will be required to satisfy the Public Trustee as to any matter which he may think fit to investigate before copies of such Report or accounts will be supplied.

Intending Tenderers who desire to inspect the property of the Company, should apply to the Public Trustee for an authority to do so.

Tenders must be delivered, sealed, to the Public Trustee, Kingsway, W.C., on or before Thursday, the 14th June, 1917 (NOT APRIL 2ND, AS PREVIOUSLY ADVERTISED), at Twelve o'clock Noon, and marked on the envelope, "Tender, Siemens Shares."

The Public Trustee does not bind himself to accept any Tender, and reserves to himself all rights in connection therewith.

Forms of Tender can be obtained from the PUBLIC TRUSTEE.

Dated this 8th day of February, 1917. 5043

C. J. STEWART, Public Trustee,
Custodian for England and Wales.

RICHMOND MAIN SEWERAGE BOARD.

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Sealed Tenders, on the forms provided, to be delivered to the undersigned, on or before Tuesday, May 8th, 1917.

Security for the due fulfilment of the Contracts will be required in accordance with the provisions of the Public Health Act, 1875.

The Board do not bind themselves to accept the lowest or any Tender.

J. LESLIE G. POWELL,
Clerk to the Board.

The Sessions Hall,
Richmond, Surrey,
11th April, 1917. G 580

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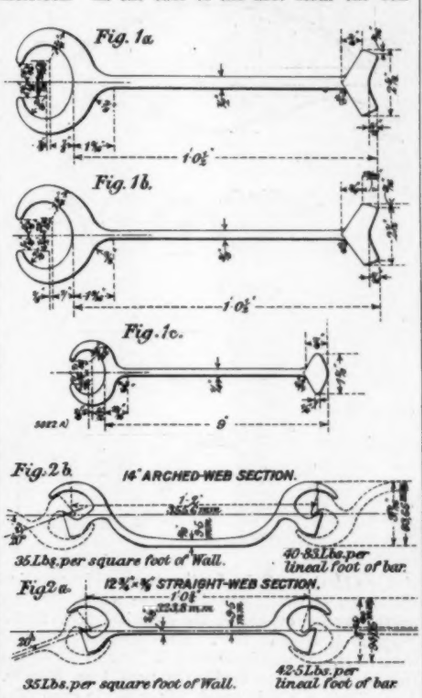
STEEL SHEET PILING: AMERICAN PRACTICE.

THE tendency in American practice in respect to steel sheet piles, especially the heavier forms, is to use shapes which are finished when they leave the rolling mill. Such sheeting has no rivet heads, and has, in fact, precisely the same horizontal section from head to foot. There are three principal varieties. In the one (see Figs. 1*a*, 1*b* and 1*c*) it will be noted that we have a section symmetrical with respect to a longitudinal axis, but unsymmetrical with respect to a transverse axis. Of the second form (see Figs. 2*a* and 2*b*) precisely the reverse remark may be made. Of the third, we may say that either of the two pieces which together form a unit is symmetrical to both axes. Since it is usual to handle this piling in units consisting of two pieces assembled together, there is a right and left. Certain practical results grow out of these facts. With regard to a piling of the first form, it cannot cause trouble by being turned upside down; but there is a difference between right and left. A wrongly set pile needs only to be turned round on a vertical axis. With the second form we have no right nor left; but the pile may be set upside down. It may be brought right, however, by simply turning it round on a vertical axis. As to the third form, we may deal with the double units as with the first form. Accordingly, in no one of the three cases is it possible to lay the piles in storage or set them for final position in such a wrong way that a mere reversal of the faces will not correct it. This advantage is possessed by other forms as well as those illustrated.

It will be noted that the interlocks vary greatly. All agree in resisting separation in all directions except the vertical. This is as it should be. Sheet piling is put in vertically to form a vertical wall; but horizontal pressures bend the piles. The interlock should resist these pressures, as they tend to disrupt the wall. This remark applies both to piling used for temporary service and that put down to act as a curtain wall and the like. Now, while all the interlocks shown resist being opened, yet they are not all the same with regard to the flexibility of the mutual grip. One pile of the first form may deviate slightly from the plane of its companion, but only slightly. Errors in driving may be corrected if not too pronounced. Metal shims may be used to secure the slight deviations possible, or the new pile may be held by ropes or the like. The second form has a very flexible interlock—so much so, in fact, that deviations of 15 deg. and 20 deg. may be made. Under certain conditions this flexibility is a decided advantage. A circular wall may readily be put down, or a boulder in the line of the wall may be passed by curving the steel diaphragm around the rock. There is a companion disadvantage—we need in driving this type of piling to be constantly on the alert lest we lose alignment. A deviation is, however, of no consequence, since the very flexibility of interlock which permitted it may be utilised to correct it. The third form of piling has an exceedingly inflexible interlock. If we drive our first pile absolutely to the vertical, all the rest will be vertical as a matter of course. But an error in driving this first pile is not susceptible of correction later on with the other piles. In case a boulder is struck, we may sometimes displace it, if conditions should happen to be favourable. If, however, the unexpected rock is big and stubborn, we may have to sink a pit and blast it. Or we may be successful with drilling from the general surface down into the boulder, and thus securing an opportunity to blast. Heavy steel sheeting is capable of penetrating rather serious obstructions. When the new pile must deviate in alignment from the old, we will ordinarily have to bend it along a vertical corner. This may or may not be convenient.

If we look at these three varieties of rolled forms with an eye to salvage after temporary use, we must conclude that the third form has the greatest possibilities. Nearly the whole of the weight of a double unit consists of a typical I-beam, usable as such. All the forms may be used over and over again as steel sheet piles. This re-use has become quite customary. In fact sheet piles have been used forty or more times. There are no attached pieces to get loose or tear off with the rolled forms.

It is often desirable to make a wall of piling watertight. In American practice this condition is secured in several ways. If a moderate degree of watertightness is deemed sufficient, the interlock itself may need no sealing. Of the three rolled types, the third has a very fair degree of tightness as it stands. The other two have interlocks more or less open. Still other types of sheeting have various degrees of tightness up to a very fair degree of perfection. In some situations, and for some purposes, an interlock will automatically gather more or less material and become tighter. For permanent work where absolute tightness is desired, doubtless the best plan is to use piling having one of the more open interlocks and fill it with a suitable seal. Cement grout will appeal to some. In order to make a certainty of filling the space with the grout it will be necessary to have a clear space from top to bottom in the interlock. The ways of doing this will vary with the varieties of open interlock. In the case of the first form the conditions will ordinarily be as follows. The ball edge of the last pile driven will be down in the ground, surrounded on all sides except the web by the earthen strata. The encircling socket of the next pile is to be driven down over the enveloped ball edge. As usually driven, the socket would simply leave a core of earth in place, filling to a greater or less extent the interlock space. One method of dealing with this situation proceeds by making use of a cast-iron shoe. This shoe is provided with a slot on top into which the web of the new pile may be fitted. Underneath, the shoe may be given an edge to facilitate driving. This shoe should be so shaped as to extend beneath the bottom of the socket space. This extension should project horizontally beneath the socket until it touches the ball-edge of the pile already in place. A somewhat similar shoe would appear applicable to the second form of rolled piling. The object in view is simply to force the earth away from the interlock space. As the interlock space of the second form is double, it would appear desirable to use a shoe extending beneath the pile from near the extreme edge of one side to near the extreme edge of the other side. The use of a shoe is, however, scarcely the last of the points to be noted. The interlock space will often, if not generally, contain water. The specific gravity of Portland cement grout will be, say, double that of water. In an unconfined space, the grout would certainly settle to the bottom, allowing the water to take position above it. It seems doubtful whether we can always depend upon this interchange of positions in such a small space as that between piles. Possibly such a situation may be well met by the use of a long slender tube as a means of introducing the grout by a kind of bottom pouring. If one does not favour cement, he may turn to oakum. This material may be forced in with long rods. Still another method depends upon effecting a seal by means of wooden strips made from a wood that swells upon becoming soaked with water. Spruce is one such wood. With permanent work the engineer will naturally have to take into consideration whether a wooden seal will be indestructible. If the piling is perpetually submerged there seems to be no reason why a spruce seal should not have the long indefinite life of a constantly submerged wooden bearing pile.



The manner of using a wooden seal needs, perhaps, further explanation. Consider the interlock of the first of the three rolled forms. Here we have, in section, a circular opening in one pile partially filled with the "ball" of another. The wooden strip is put in the plane of the webs of the pile sections and between the ball and that part of the socket opposite the web. The normal effect is to force the two units to occupy the maximum area. The packing strip is made half-round in section or rectangular. In the former case the rounded part tends to conform to the steel surface. There is some objection, however, to this, as the frictional resistance is said to be greater than with the rectangular strip. In neither case is the wooden strip driven alone. It is set in place in the socket and held there by wooden wedges scattered along the length of the slot of the socket. These wedges may be driven into the slot transversely to the pile. The socket and its wooden strip are together driven over the ball. The wedges are disposed of in the driving operation. When using the rectangular wooden rod the shorter dimension of the rectangle is put in the plane of the webs. It is understood that the wooden packing of both shapes swells and thus completes contact with the metal of the piling. It should be understood that the procedures described as effective for sealing the first type of piling with wooden strips may also be used with modifications in other and similar cases where the character of the interlock permits.

Seals are made in still other ways. Thus, coal dust, whole wheat, rice, wood sawdust, &c., may be filled into the interlock space and allowed to swell in the presence of water. Naturally, these materials should be dry at the moment of application, so that the swelling may occur after placing. Street sweepings, manure or oatmeal may at times be externally applied with a measure of success. Thus, in the case of a cofferdam, such materials may be suitably placed on the outside of the wall of piling. As the unwatering within the cofferdam proceeds, the suction tends to carry the materials into the interlock. These methods may be sufficient in many cases, especially cases of temporary installation of the piling.

Sheet piles of the rolled forms may be secured from the mills in lengths up to 45 ft. for one or two light sections and up to 70 ft., or perhaps more, for other weights. However, it is not always convenient to transport such long lengths. Then there will be cases where piling is to be driven in lengths not easily obtainable. Sometimes the head room is not sufficient to permit the full length of piling to be put down at once. Under such conditions as are indicated by the foregoing, or under conditions which make it desirable to use piling already on hand, it will at times be desired to splice some or all of the lengths. The word "splice" is here used to include the putting of one pile vertically upon another even where there is no actual joining of the two. A little consideration will show that the driving of unconnected lengths of piling, one upon the other, introduces difficulties. Particularly is this the case with the first pile down. But even with the next we may expect trouble with the interlock then being completed. A rather general method of overcoming the difficulties without the use of splicing pieces or guides has been developed. We may describe it as it can be applied to a wall to be made up of two-piece piles (see Figs. 3*a*, 3*b*, 3*c* and 3*d*). Naturally, we will want to stagger the breaks. The first thing to be

done is to drive to their full length the bottom pieces. These will alternate between long and short lengths. Assume that the leading pile of the group is a long piece. Next set in place the follow-up piece for the third pile already in, which will be a long one. We go ahead with driving at the third position, but do not permit it to proceed far enough to overtake the bottom of the short length in second position. Then put in place and drive the remaining follow-up lengths—all except the final two. But we do not finish. We may stop when the tops are at about the level of the top of the follow-up in the third position. Beginning now at the fourth position, we drive to full penetration the piles at every position in turn until we have driven the third from the end. One single pile will at this stage be projecting above the final top level. This is the pile in the third position from head. We now use the follow-ups belongings to the first and second

DIAGRAMS SHOWING METHOD OF DRIVING SPLICED PILING.

Fig. 3a. BOTTOM SECTIONS DRIVEN THEIR FULL LENGTHS.

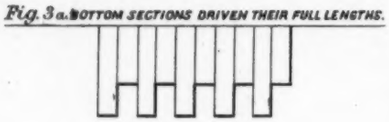


Fig. 3b. FOLLOW-UP OF 3RD PILE PARTLY DRIVEN.

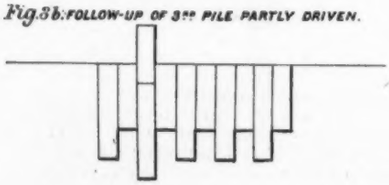


Fig. 3c. ALL PILES EXCEPT FIRST TWO AND LAST TWO DRIVEN TO POSITION OF 3RD PILE AS SHOWN IN VIEW PRECEDING.

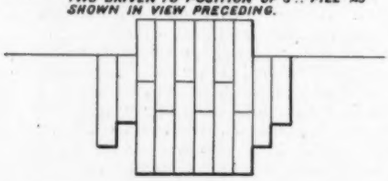
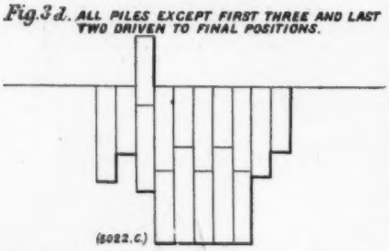


Fig. 3d. ALL PILES EXCEPT FIRST THREE AND LAST TWO DRIVEN TO FINAL POSITIONS.



positions. We may start at the second position, but may need to be careful lest we lose the interlock at the break between the two parts. In order to avoid this we may stop driving until we have forced further down the long piece in the first position. Having finished at the first two positions, we go to the final two and do the driving in just about the same way. The vital thing to keep in view is never to lose the interlock or to get the incompletely driven piles into such positions that the loss of the interlock will somewhere be inevitable in the subsequent driving.

Splice pieces are useful where spliced piling is put in temporarily and is later to be withdrawn. Flat plates or channel-bars may be used, two to a joint. These will pretty well cover the webs horizontally. Vertically, they will be long enough to provide suitable overlaps to accommodate the necessary bolts and to furnish the needed rigidity. Naturally, the channels give a rigid splice. They are, of course, placed back to back, with the pile webs between. There should be plenty of bolts used. The holes in the webs are the ordinary round bolt holes. On the other hand, short vertical slots are used in the splice pieces. The purpose of the slots is to prevent the transmission of the driving impulse through the splice pieces. Their purpose is a single one—namely, to maintain vertical alignment between the two lengths of piling and to assist in the pulling of the under length later on. The bolts when in use should, of course, be drawn tight. For piling whose web exceeds $\frac{1}{4}$ in. in thickness, channel-bars will ordinarily be suitable. For thin webs, flat plates may be used, but they may well be thicker than the pile webs with which they are to be employed.

With the two-piece unit—the third rolled form—splicing may be made a simple matter, provided we use lengths of the connecting bar that differ from those of adjacent I-beams.

An interesting instance of spliced piling is afforded by the construction of the cofferdam in Havana Harbour, Cuba, for the purpose of recovering the wreck of the battleship Maine, which had lain on the bottom ever since the days just prior to the Hispano-American War. The lengths required were 75 ft. It was inconvenient both on shipboard and at the job to deal with such long lengths. Accordingly, a single break was made in each pile. For the bottom pieces lengths of 40 ft. and 50 ft. were used in alternation, thus staggering the joints. This procedure entailed splicing on 35-ft. and 25 ft. pieces after the bottoms had been driven until their tops were just above water. A representative splice was made by using two 7-in. channels set as already described. Each channel was 3 ft. long. Sixteen bolts of $\frac{7}{8}$-in. size in two parallel longitudinal lines were used. The bolts were placed two abreast. All bolts were set $4\frac{1}{2}$ in. apart, centre to centre. The channel-bar used weighed $12\frac{1}{4}$ lb. per lineal foot. The punching of the 16 bolt-holes in each channel-piece was done as a single operation, as was also the punching of the eight holes in pile ends. The strength of the bolts was found adequate to the subsequent pulling operation. The piles were used to form walls for cylinders 50 ft. in diameter, and for connections between cylinders.

Certain types of piling are subject to a forward creep at top or at bottom. Such piles are, naturally, those whose interlock is more or less flexible in the plane of the webs. With such piling one needs to be on the alert to discover the creep as soon as it begins, and consequently before it has had time to accumulate into a considerable total. Bottom creep may often be corrected by forcing the tops ahead. This is done by introducing wedges, nails, spikes or the like into the top interlocks as the driving goes on. Cables may be used to prevent top creep. Naturally, a creep which has been allowed to go uncorrected may, because of its total amount and the fewness of the piles which are yet to be driven, be past correction. Difficulty may ensue in effecting closure with the final units. A wedge-shaped pile is sometimes used in such circumstances. Such a pile is made by splitting one of the normal units along a longitudinal line on the web, cutting a wedge-shaped piece off one or both the separated edges and then reuniting the main parts of the pile by means of riveted-on strips or by some other means.

In driving, the units of the first rolled form should be driven with the ball ahead. That is, the new pile contributes the socket to the new interlock just being formed. With the second form the faces are reversed continually as we pass from one pile to the next. With the third form the two parts are driven as a unit.

There are various other pile forms employed in American work. These are chiefly sheet-steel forms. Thus in Fig. 4 is shown a simple steel plate bent round a vertical axle of curvature and given suitable interlocking hooks at the sides. The curvature adds to the rigidity. This piling is assembled with concavities and convexities alternating. It might be thought that this would result in wasting space perpendicularly to the wall of sheeting. But the total variation from a plane surface is in reality small. Another type of steel-plate sheet piling has vertical corrugations such as shown in Figs. 5*a*, 5*b* and 5*c*. These corrugations are made on radii of curvature of but an inch or so. Accordingly we get great stiffness relatively to the weight of the metal. The interlock is made by overlapping edges and securing one or both by vertical straps riveted on to the piling. Sometimes the straps are not continuous, but are broken up into short and separated lengths. In driving piling of these classes it will usually be good practice to hammer shut the interlock opening on the forward side at the bottom of the pile about to be driven. This tends to prevent rupture or distortion and to keep the interlock clear. When the next pile goes down it opens out the interlocking space. The first two rolled forms are obtainable with $\frac{1}{4}$-in. webs. The second form is now obtainable with a web thickness of $\frac{7}{32}$-in. Plate steel sheet piling is obtainable in still thinner metal.

Fig. 4.

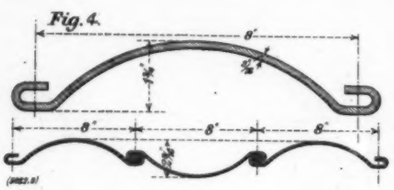


Fig. 5a.

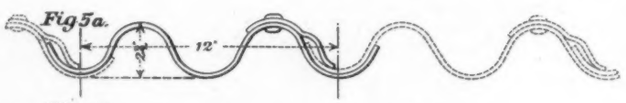


Fig. 5b.

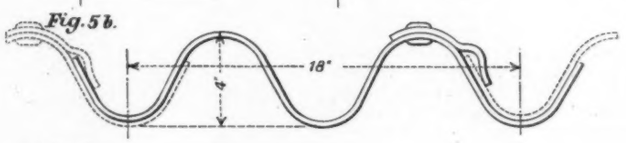
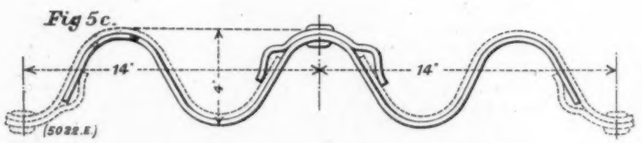


Fig. 5c.



The driving of light-weight steel sheeting may very frequently be done by hand. A wooden maul will often be sufficient. Where hand-driving is possible, it will at times be the economical thing. Or a portable machine will be advantageous. A striking instance in point is afforded by a job carried out in Pennsylvania. The contractor had in hand the laying of a 42-in. steel pipe across a shallow and not wide arm of water. It was proposed to use steel sheeting to shut off the water from the immediate site of the laying. The trouble and expense of fitting up a scow and installing on it a pile-driver were obviated by the use of thin sheeting capable of being driven by hand or by a small portable pile-driver. Two parallel rows of the piling were carried from one shore to about the centre of the water. These side walls were connected by a short transverse row of the piling. Here was a good cofferdam. The natural tightness of the sheeting was increased by dumping the spoil

from between the rows of piles up against the piling on the outside. The pipe was laid to about the water end of the cofferdam, whereupon it was only necessary to repeat in effect the former procedure. The steel sheeting used on this job weighed only 7½ lb. per square foot of wall surface. There was accordingly no trouble in handling the individual piles by hand. An approved method of putting down light-weight piling is to use a very small sheet-pile hammer operated either by steam or by compressed air, such as is illustrated in Fig. 6. The man gets on a bracket on the machine and operates it as he stands there with the apparatus mounted on the pile. Such a pile-driver need weigh no more than 115 lb. The effective blow of the hammer is said to be more than double its own weight. The blows are given in rapid succession. An excellent American authority states that this type of machine is more effective than three men with mauls.

Light-weight sheeting, and also heavy piling, may at times be very advantageously driven with a water jet. The essential conditions are pressure water and responsive material. Such material as mud, soft clay and clear sand will ordinarily respond to the jet. If, however, the material is hard clay or a sand containing a heavy percentage of gravel, the water jet is an inadvisable adjunct. A supply pipe of 1-in. diameter and a ¾-in. nozzle will be suitable for moderate weights of piling having a width of, say, 13 in. or less. Fig. 7, annexed, illustrates the carrying out of this mode of sinking.

FIG. 6. DRIVING LIGHT-WEIGHT PILING BY SMALL SHEET PILE HAMMER.

FIG. 7. SINKING SHEET PILING WITH A WATER JET.

Steel sheet piles may be driven by the same general methods as those used with bearing piles. However, the ordinary gravity hammer seems to have come into a measure of disrepute in connection with the driving of steel sheeting. It is objected that, "owing to the length of time consumed in hoisting, the interval between blows is great, and much of the work of the high-velocity blow is wasted in bruising and battering the top of the pile, in overcoming the inertia regained after each blow, in producing needless vibration, &c."

There is a modification of this apparatus which seems to be more satisfactory. The gravity drop is retained, but instead of lifting the hammer by means of a power or man-operated hoisting drum, steam pressure is applied in a very direct manner. We are readily able to secure the advantageous combination of a heavy hammer, a short drop, and a quick return lift. A well-known pile-driver of this type is one based on the old-time English Nasmyth hammer. The improvements are due to J. N. Warrington. "Its chief characteristics are a simple and positive valve gear, a short steam passage, and a quick and wide opening of exhaust, avoiding both waste steam and back pressure during the drop, turned columns connecting the cylinder and base, and a piston forged on its rod, with a channel-bar attached on each side to enable the hammer to drive below the bottom of the leads. The cylinder is long and vertical, with steam ports at its base. The piston is solid and the ram short, heavy and solid, except for the piston-rod cavity, thus concentrating the weight of the ram as low down as possible."

The double-acting steam hammer goes a step farther, in that not only is the ram raised by steam pressure, but it is also dropped with the assistance of steam. This arrangement makes possible a reduction of the lift, since the steam pressure exerted on the piston is added to the force of gravity, giving an increased velocity of drop. There are several varieties of this species of hammer pile-driver in regular use in the States.

The percussion piston hammer is distinguished from this last type of pile-driver. The principle of the air drill serves here as a guide. There is added a heavy base which rests on the pile top. The piston strikes directly on the heavy piece—the anvil. There are various modifications of this device. Vibration in the pile is stated to be more or less obviated by the weight of the anvil block. Some of these hammers have a step upon which an operator may stand. His weight is thus added.

In determining what weight of hammer to use in any particular case, the resistance of the soil to be penetrated will naturally be taken into account. Moreover, the weight of the pile itself should also enter into consideration. The hammer "should be sufficiently heavy to permit the pile to absorb its share of the blow and still have surplus force to put the pile in motion." Where old-time gravity drops are used it is better to use a heavy hammer and a short drop rather than a light hammer and a long drop. "As compared with hoist-operated gravity hammers, the advantage of the steam hammer lies in the fact that the weight of the entire hammer is constantly on the pile, and, in addition, blows of low velocity delivered at frequent intervals keep the pile in continual motion, and no opportunity is afforded for the earth to become packed around it to increase its friction, as is the case when longer periods of time elapse between blows. In like manner in driving large and heavy piles a heavy ram with a moderate number of blows is preferable to a light ram with frequent blows."

It is quite customary to pull piles that have been used in temporary service. The cost of pulling is considerable. While, in general, it is not as great as the cost of driving, still it is to be rated as equal to a large percentage of the expense of driving the very same piles which it is proposed to pull out again. This percentage may run as high as 75 or even higher. Where the piling has been driven with a wooden maul, or could have been so driven, a simple lever may suffice. This lever may have attached to it metal straps or other devices to facilitate connecting the pile head with the lever. Simple perforations in the top of the pile serve for the introduction of bolts or pins. Ordinary hoisting arrangements may suffice for these piles and for still heavier sheeting. Hydraulic jacks have been used for rather difficult pulling. The jacks may be used mainly for starting the units. By setting up jacks on the heads of the adjacent piles they may be brought to bear beneath a head block provided with a slot through which the intermediate pile may pass on its way up. Another method that has been used simply sets up a framework provided with a strong cross-piece, to which blocks and tackle may be rigged. The line may be operated by hand or by power, as circumstances may require. A rather novel method was used in New York in pulling piles which had been put down to a considerable depth. A percussion-piston pile-driving hammer was hung upside down from a derrick boom and used thus to pull the piles. "In pulling, the inverted hammer takes hold of the pile by means of the shackle, and steady tension is then exerted on the pile line, which pulls the shackle strap down upon the anvil block, and the hammer is placed in operation. On this job piles of 26 ft. penetration in clay, sand and gravel were withdrawn in from 2 minutes to 10 minutes each, without distortion." Piles that are driven correctly will pull out more easily than where there have

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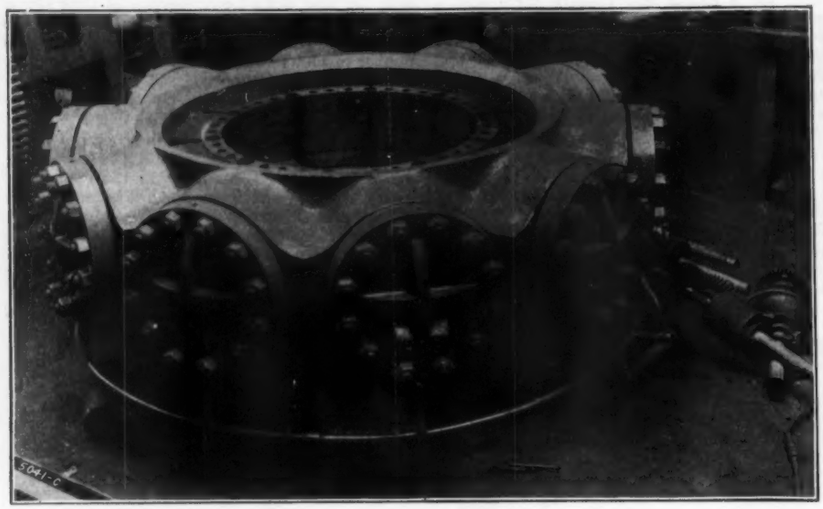


Fig. 1.

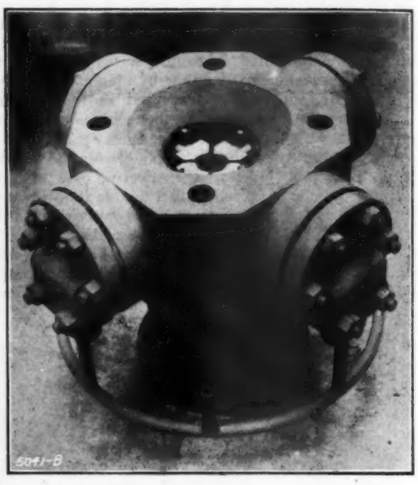


Fig. 2.

been all sorts of deviations of alignment, &c. When piles rust together we have an additional resistance. This difficulty may often be more or less perfectly obviated by properly greasing the piles at the time of driving.

Sometimes all the sheet piles in a given unit of construction are assembled prior to beginning actual driving operations. This is especially the case where a circular wall is to be put down. The piles are then driven a little at a time, one after the other. By this procedure closure difficulties are avoided. But the custom is by no means universal. Especially where there is a considerable total length of wall the contractor is apt to take chances on closing. If he loses vertically he will know it before reaching the terminus—that is, he will probably know it in time to provide for correction. If the wall is a closed figure approved practice seems to require that he should make the closure a little to one side of the corner at which he began.

The formation of corners is a matter which cannot very well be neglected. Some types of piling are of such form that a simple corner is most easily rounded by using a pile bent to the proper angle in the web. It is good practice to begin driving with such a corner pile. Where the corner-piece is to provide for three or more different walls of sheeting, it may be necessary to split one pile longitudinally in the middle of the web and unite one or both to the web of a perfect pile. Angle bars will be useful in effecting these unions. It will be understood from this that web is not joined directly to web, but that in effect web is riveted to angle bar and angle bar to web. Single rivets will occasionally include in their grip three thicknesses of metal.

Driving caps are much used. For certain types of piling the light weights may very well be dealt with with a fabricated cap—that is to say, with a cap made from a square or rectangle of heavy steel plate by riveting to its under side short pieces of angle bar to form a groove or slot to receive the web of the pile head, and by riveting to its upper side other pieces of angle bar to provide for the retention of a wooden driving block. Heavier caps are made as special castings. Undoubtedly it is in general best to use a cap. The pile head is then held to position and a better distribution of the hammer blow is probably effected.

The cost of driving steel sheeting will, of course, vary with numerous factors, so that no reliable general rule is at present available. It may, however, be of interest to state cost data relating to the driving of 19,654 lineal ft. of 12-in. rolled piling of the first type. This piling weighed 40 lb. per

Fig. 3.

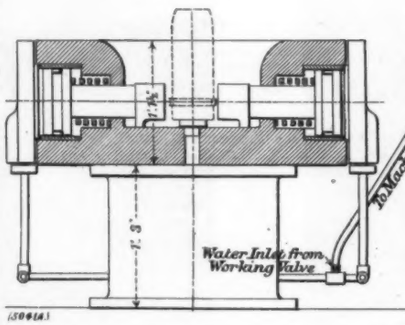
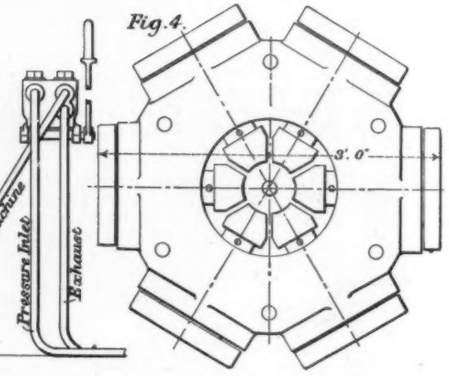


Fig. 4.



lineal foot. The material penetrated was sand and clay, and the piles varied in length from 40 ft. to 60 ft. Twenty-one working days of 10 hours each were consumed on this work. Maintenance and operation are put at 7 dols. per day. Nine men, including a foreman, an engineer and a fireman, constituted the crew. Their combined daily wage amounted to 28.50 dols. The expense for 21 days, including a 60-dol. item for handling and incidentals, totalled 805.50 dols. The total cost per foot of penetration is given as 0.041 dol. Estimated on the basis of the weight driven, the cost was 2.05 dols. per ton of 2,000 lb.

The driving of piling the heads of which will be submerged occasions more or less difficulty. Various methods have been adopted. An air-driven hammer, also submerged, has been used. The water naturally interferes more or less with the energy due to the blow of the hammer. It has been proposed to enclose the working parts of certain types of hammer and to fill the compartments with compressed air. The stroke would be but little retarded by the greater density of the air, while the air pressure could be used to exclude the water. However, we are not aware that this method has anywhere been followed. The customary method is to make use of a follower. This consists of a length of piling, of the type and weight being driven, reinforced with channel-bars riveted back to back with the web of the pile between. The channels project on the lower end. The head of the pile being driven fits into the slot thus formed. The driving is effected through the follower. This method applies to the rolled forms. There are types of sheet steel piling which could scarcely be handled in this way. The channels run all the way to the top of the follower, thus reinforcing it throughout its entire length.

SHRINKING OR BANDING PRESSES.

On the present page we illustrate two sizes of shrinking or banding presses, constructed by Messrs. Hollings and Guest, Limited, of Thimble Mill-lane, Birmingham. Fig. 1 shows a very powerful press with 10 rams, capable of giving a pressure of 1,500 tons. This can be fitted with segments of various sizes to adapt it to different types of work, and can compress hoops and tyres of large cross-section and considerable diameter. Fig. 2 is for shrinking copper driving bands on to shells of moderate size. The shells can be dropped and taken out by a girl at a very rapid rate and without undue fatigue. This press has four rams.

Figs. 3 and 4 are vertical section and plan through a press with six rams, and illustrate typically the construction of all sizes of these presses. It will be seen that each ram is fitted with a leather, while the cylinder is lined with gun-metal. A spring surrounds the forward end of the ram and returns it as soon as the pressure water is cut off by the control valve, and the cylinders are connected to the exhaust. The tools are fitted to the ends of the rams. An arrangement is fitted on the large machine to make the tools work evenly inwards and outwards together, keeping the circle all the time. The shell is centred by an internal mandrel, the end of which drops into a central hole in the bed. The whole arrangement has been well worked out, and is exceedingly handy for rapid working.

Patent Fuel in the United States.—According to *The Railway Age Gazette*, New York, the production of fuel briquettes in the United States in 1916 was 295,155 net tons, valued at $1,445,662, an increase, compared with 1915, of 73,618 tons, or 33 per cent., in quantity, and $409,946, or 40 per cent., in value.

DALE'S TOOL FOR CUTTING THREADS IN THE LATHE.

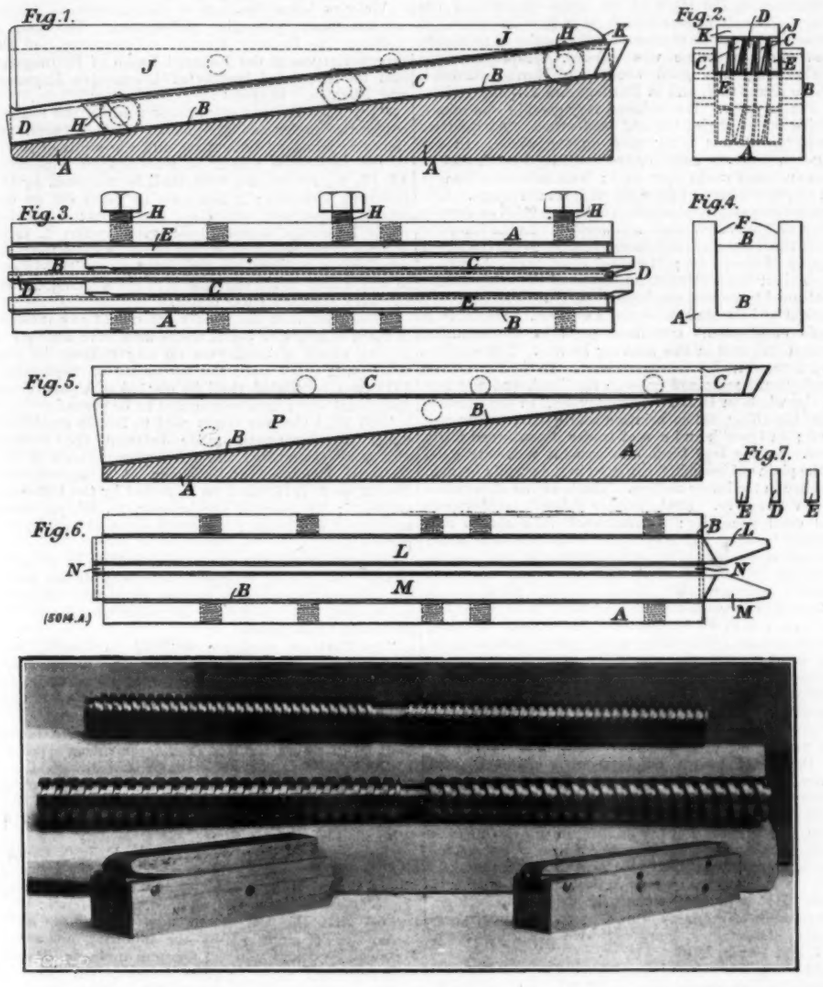


FIG. 10.

THE tool illustrated on this page is designed for cutting square thread screws, worms, and the type of screws called "acme" threads, which are used for lathe leading screws. For cutting multiple-threaded screws its advantages over the ordinary methods will be clear when it is stated that all the leads are cut together by two, three or more tools operating at the same time.

In cases where a quick lead is desired without unduly weakening the screw, a multiple thread is a distinct advantage. When cut by the ordinary method, that is, with one tool only operating, it is necessary to cut each lead separately, which takes extra time. Another difficulty with multiple-threaded screws of certain pitches is to divide the pitch equally so that each thread shall be of equal thickness, the change wheels not allowing of equal division. By the use of multiple tools the above difficulties are avoided.

Fig. 1 is a side elevation of the tool-holder with tools in position for cutting a double-threaded screw. Fig. 2 is an end elevation of Fig. 1. Fig. 3 is a plan view of Figs. 1 and 2. Fig. 4 is a back-end view of the tool-holder. Fig. 5 is a side elevation showing tools in position for cutting an acme or worm thread. Fig. 6 is a plan view of Fig. 5. Fig. 7 shows detail end views of the taper strips and a distance-piece used for giving the correct angle to the tools and spacing the tools correctly when cutting square threads.

A is the channelled bar or tool-holder, in which is a slot B of varying depth, to give the necessary top rake to the cutting tools C secured therein. The tool-holder may vary in size according to the size or number of tools it can contain, and, in the case of square threads, if more than one thread is required, any number of threads corresponding with the number of tools contained in the holder may be cut together by placing distance-pieces D of the correct thickness between the tools, whilst the correct angle for the tools is obtained by the taper strips E, E, being placed on the outside of the tools adjacent to the sides F of the tool-holder, as shown at Fig. 2, the taper varying with the pitch and diameter of the work. The strips E are also arranged with the taper sides parallel, so that on the insertion of the tools and distance-pieces they automatically cant to the correct angle for the work required.

The tools, strips and distance-pieces are preferably secured in the holder by the set screws or grub screws H, and when fixing the tool-holder in the slide rest of the lathe a taper bar or tongue-piece J is employed, which gives a horizontal surface on the top of the tool-holder and enables the tool plates of the rest to bed on substantially. The bar J also has a bevelled or bull nose K, which diverts or turns aside the cuttings and keeps the work clear.

In the case of worm or acme threads, Figs. 5 and 6, the tool is formed in two parts L, M, shaped so that the metal is removed from the side of the thread, thus allowing the cuttings to clear more efficiently and reducing the tendency to jar or chatter. By inserting a distance-piece N of the requisite thickness between the tools L, M, the pitch of the screw or worm may be varied as desired. A taper bar or tongue-piece P in this case is placed in the bottom of the slot B to secure the tools horizontally, and when the tool-holder is placed in the slide rest the tool plates bed upon the top of the tools, which in this case project above the sides of the holder.

The chart, Fig. 8, shows clearly how the requisite slope is obtained for any pitch and diameter. The diameter of the screw is shown on the vertical line, each distance being actually the circumference for the diameter given. The pitch of the screw is measured on the horizontal lines. A straight-edge placed in line with the point C and the point of intersection of the vertical and horizontal lines corresponding to the required diameter and pitch will give the slope in degrees on the scale above. This gives the required angle for the taper strips.

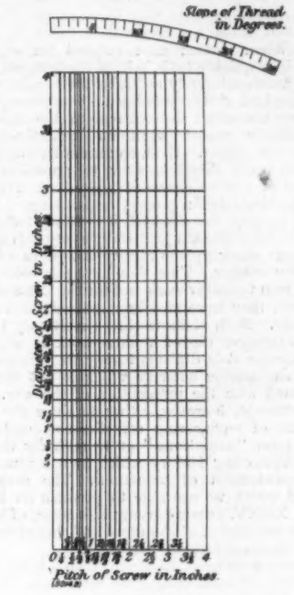


FIG. 8.

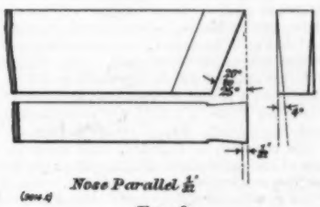


FIG. 9.

The distance-pieces and the tools, Fig. 9, are of the same width exactly, and this may be obtained in the following manner. For example, take a double lead screw. The width of the threads is one-quarter of the pitch. The width of the thread at right angles to the thread is W cos θ, where W = width parallel to axis of shaft, and θ = the angle of slope, which is found from the chart.

The rigid form of the tool-holder conduces to rapid cutting for all types of screws, and it is claimed that a great saving in tool steel is effected by the shape of the tools, which are of the same section throughout the length. Fig. 10 shows two square thread screws, right and left hand, one having two leads and the other three leads, with the tools in position in the holders with which they are cut. The tool-holder is the invention of Mr. A. F. Dale, of the Municipal Technical College, Halifax.

THE HAMBURG-SOUTH AMERICAN STEAMSHIP COMPANY.—The above company, contrary to what is the case with a number of large German shipping companies, has not availed itself of the permission granted to such companies not to publish any balance sheet during the war. Consequently additional interest attaches to the glimpse which the said balance sheet affords into the state of German shipping at present. It is not encouraging from the German point of view, as will appear from the following table :—

—	1916.	1915.	1914.	1913.
	marks.	marks.	marks.	marks.
Profits of working	400,000	2,900,000	5,300,000	11,400,000
Writings-off ..	0	0	3,100,000	7,000,000
	per cent.	per cent.	per cent.	per cent.
Dividend ..	0	4	4	14

A number of the company's ships have during last year been employed in the Swedish iron ore trade; the reason for the reduced working profits does not appear from the balance sheet. The company has seven cargo steamers on order.

WOMEN WAR MUNITION WORKERS.

THE term "munitions" has unfortunately become in the public mind restricted to shells, perhaps because the cry for shells became most clamant and the need most obvious when the war settled down to trench fighting. When women were enlisted for munition work the idea quickly took hold of the general public that they were exclusively utilisable for turning shells, and the standard of their intelligence was consequently regarded as somewhat depreciated, as the operation was practically repeat work on specially-devised carefully set machines. Even engineers and managers of factories were therefore slow to apprehend the possibilities of a more extended utilisation of women workers, particularly in general engineering.

All this, happily, has changed, and slowly but surely women now find a place in practically every engineering establishment, doing a great variety of work in a highly praiseworthy manner. Thus they have released a large number of men for other work and for the Colours; or, alternatively, they have greatly increased the volume of work done. Both of these aims abundantly justify the most extensive use of women workers which is possible, because it is difficult to-day to indicate any branch of engineering activity which is not more or less concerned with the prosecution of the war. We shall not attempt, however, either to show the wide ramifications of engineering contributions embraced under the term "munitions" or to seek for the exceptional engineering factory which is not concerned with the production of munitions. The series of illustrations which we are able to produce on Plates XXXII to XXXV, accompanying this issue, of themselves carry conviction of the great and varied service that the women workers are rendering.

The four views (Figs. 1 to 4) on Plate XXXII illustrate a variety of work being done by women in completing the cylinders of reciprocating engines required for mine-sweepers, and in every case there is demanded close attention and a large degree of intelligence. Fig. 1 shows one of Harvey's borers with a cylinder on the bed, while Fig. 3 illustrates a corresponding operation being carried out on the valve chest. Fig. 2 shows the columns being marked off on the surface table, while Fig. 4 illustrates a planer at work on the cylinder.

The views on Plate XXXIII are more varied, and even more interesting. Fig. 5 shows women at work making the cores in a foundry, and there is clear suggestion of adequate physical strength of the workers for lifting the moderately heavy weights. Fig. 6 is a view of the condenser shop, where the whole of the work of inserting and packing the tubes in the condensers for marine engines is carried out by women. The next two figures on this plate show work being done on Clerget rotary aero-engine cylinders. Fig. 7 shows the cylinder in a Dean, Smith and Grace lathe, for the final turning and adjustment of the ribs—work done to a limit of 0.025 mm., so that it will be recognised that great care and intelligence are required. This applies with almost equal force to the work being done in the case of Fig. 8, as here the limit is 0.05. The view shows an ordinary Becker milling machine engaged, under the supervision of a woman worker, in milling the top of an aircraft engine cylinder. It may be stated that in this case the women sets the tool in the machine as well as the job.

Figs. 9 and 10, on Plate XXXIV, illustrate the building of aeroplanes, which is more or less carpentry work, requiring deftness and the exercise of great care. Fig. 11 is in sharp contrast to Fig. 12. In the one case a woman worker is engaged in the delicate and minute operation of dividing pearl dials for prismatic compasses, while in the other she is employed in roughturning the jacket forging for a large howitzer.

On Plate XXXV there are two further views of work with these 60-lb. howitzers. In the one case the breech ring is being turned, bored and screwed (Fig. 13); in the other the profile of the breech ring is being slotted (Fig. 14). The last of the series of views (Figs. 15) shows the operation of milling the coupling rods and spring links for a locomotive. This is quite appropriately included in munition works, because the forwarding of supplies to the port of embarkation in this country, as well as the carrying of them up to railhead behind the fighting line, is as necessary as the firing of the shells from the guns into the enemy's entrenchments.

IRON AND STEEL INSTITUTE.—Mr. G. C. Lloyd, secretary of the Institute, informs us that a "Note on the Properties of the Refractory Materials used in the Iron and Steel Industries," by Mr. Cosmo Johns, F.G.S., will be read and discussed at the forthcoming annual meeting in addition to the papers referred to on page 360 *ante*.

MINISTRY OF MUNITIONS.—CATALOGUES.—A collection of catalogues is being made at the Explosives Department of the Ministry of Munitions, Storey's Gate, Westminster, and any engineering firms who think that the Department would be interested in their manufactures are asked to send in a copy of their catalogues.

INDUSTRIAL NOTES.

THE Director of the Department of Labour Statistics, dealing with the state of the labour market in *The Board of Trade Labour Gazette*, says that nearly all the principal industries continued fully employed in March, and much overtime was worked. Employment in coal-mining was good except in Northumberland, where it was dull, and in Durham and Fifeshire, where it was only fair. It continued very good in iron mines, and good at shale, tin and lead mines. At quarries employment was fairly good on the whole. In the pig-iron industry employment continued good, and at iron and steel works very good; both industries showed an improvement as compared with a month ago. The engineering and shipbuilding trades were still extremely busy, and much overtime was worked. In the tin-plate trade short time was still worked owing to the restricted supply of steel bars; the steel sheet trade, however, showed an improvement, and most of the other trades continued to be well employed, and much overtime was worked by brass and sheet metal workers. In the cotton trade employment continued good in the spinning section and fair in the weaving branch. The woollen and worsted trades were very busy. In the linen trade employment remained good in Scotland, and was fair on the whole in Ireland. Employment in the hosiery, jute, bleaching, calico printing and dyeing trades was good; in the silk and carpet trades it continued fairly good. In the lace trade employment was very good in the plain net branch, fairly good in the curtain branch, and bad in the levers section. The boot and shoe trades were very active. In the leather industry employment was good generally; it improved with saddle and harness makers, but some short time was still being worked at Walsall. It continued fair in ready-made tailoring and in the shirt and collar and wholesale mantle, costume and blouse trades. Employment was good in the corset trade, and fairly good in the felt hat trade; with silk hatters it continued bad. Building operations and brickmaking were hindered somewhat by bad weather, but otherwise the men remaining in the trades were generally well employed. In mill sawing and coachbuilding employment continued good; in the furnishing trades and with coopers it was fairly good. Employment was good in the printing and paper trades, and very good with much overtime in bookbinding. In the glass trades employment continued good generally. It was also good on the whole in the pottery trade, though short time was still worked by makers of tiles and sanitary ware. It continued good in the food preparation trades, and much overtime was worked in some branches. Agricultural operations were hindered by unfavourable weather. Employment with dock labourers showed a decline, and was only moderate; with fishermen it showed little change. The number of seamen shipped at the principal ports showed increases as compared with both February, 1917, and March, 1916.

The changes in rates of wages (including war bonuses) reported to the Department as taking effect in March affected over 80,000 workpeople, and amounted in the aggregate to a net increase of nearly 6,500*l.* per week. The change affecting the largest number of workpeople was an increased war bonus to pottery workers in North Staffordshire. Important increases were also granted in the latter part of March to engineers on the North-East Coast and iron and steel workers in South Wales, but being dated to take effect before March, are excluded from the foregoing figures.

The number of disputes beginning in March was 29, and the total number of workpeople involved in all disputes in progress was 28,916, as compared with 11,165 in the previous month, and 58,388 in March, 1916. The estimated total aggregate duration of all disputes during the month was 202,000 days, as compared with 43,300 days in February, 1917, and 327,300 days in March, 1916.

The average weekly number of vacancies notified to all Employment Exchanges for the four weeks ended March was 44,608, as compared with 42,004 in the previous four weeks, and with 35,337 in the four weeks ended March 10, 1916. The average weekly number of vacancies filled for the same periods was 35,824, 33,856 and 27,417 respectively.

In regard to food prices in the United Kingdom, the percentage increase from July, 1914, to March 31, 1917, is 94, the several articles being weighted in accordance with the proportionate expenditure on them in pre-war family budgets, no allowance being made for the considerable economies resulting from changes in dietary, which have been widely effected since the beginning of the war, especially in those families in which the total income has not been increased by advances in rates of wages. Taking these economies into consideration, the general increase since July, 1914, becomes 61 per cent. instead of 94 per cent. In regard to retail food prices in Berlin, official figures are still lacking. According to Austrian journals, retail food prices in Vienna in January last were 171.7 per cent. higher than in July, 1914.

We give below the text of the agreements arrived at last week with the railwaymen. The first is between the Railway Executive Committee and the representatives of the National Union of Railwaymen and the Associated Society of Locomotive Engineers and Firemen. It states:—

"(*a*) That the war bonus now paid by the railway companies under the agreements made between the General Managers' Committee and the representatives of the two trade unions at meetings on September 13, 14, 15, 19 and 20, 1916, shall be increased by the following amounts: Employees 18 years old or upwards, 5*s.* per week additional war bonus; employees under 18, except boys engaged since January 1, 1915, at rates of pay which exceed by 7*s.* 6*d.* or more the rates usually paid to boys occupying positions similar to those in which such newly engaged boys are working, 2*s.* 6*d.* per week additional war bonus.

"Provided that the weekly amount of any increase in rates of wages or bonus which may have been given to any grade of employees on any railway by any arbitration court since the agreement of September, 1916, was concluded, shall be treated as a part of the additional war bonus now agreed to be given.

"(*b*) That the war bonus paid to female employees under the agreement made between the General Managers' Committee and the representatives of the National Union of Railwaymen at a meeting on November 2, 1916, shall be increased by the following amounts: 18 years of age or over, 2*s.* 6*d.* per week additional war bonus; under 18 years of age 1*s.* 3*d.* per week.

"Provided that the war bonus is not to be given to females not wholly occupied in railway duties, such, for instance, as wives of railway employees living in gatehouses and receiving an acknowledgment for attending to the gates.

"(*c*) That an employee working on Sunday and having been available for duty on the previous six weekdays shall receive for such Sunday turn an allowance of one-sixth of the amount of the addition made to the weekly bonus under this settlement.

"(*d*) That the first payment of the revised bonus shall be in respect of the week commencing April 9, 1917.

"(*e*) That the truce entered into at the meeting between the General Managers' Committee and the representatives of the two trade unions on October 1, 1914, shall continue in force."

The second agreement, between the Railway Executive Committee and the representatives of the Railway Shops' Organisation Committee and Craft Unions and the National Union of Railwaymen, is as follows:—

"(*a*) That the war bonus now granted to shop employees be increased by the following amounts: Male employees 18 years of age and upwards, 5*s.* per week increase; under 18 years of age, 2*s.* 6*d.* Female employees 18 and upwards, 2*s.* 6*d.* a week increase, under 18, 1*s.* 3*d.* per week.

"(*b*) That war bonus be not paid to any shop employees who are in receipt of their recognised district rates of wages, and who may benefit under the terms of the award issued by the Committee on Production on March 1, 1917, upon an application being made to them by the engineering and foundry trades.

"(*c*) That the first payment of the revised war bonus be in respect of the week commencing April 9, 1917."

The agreements were signed by Sir Herbert Walker (chairman) and Mr. William Clower (acting secretary) on behalf of the Railway Executive Committee, and also by the chairman and secretaries of the men's unions.

Mr. Bellamy, president of the National Union of Railwaymen, speaking last Sunday at a meeting of railwaymen at Southport, said that some people were of opinion that no settlement should have been arrived at until the women railway workers had obtained the same advance as the men, 5*s.* instead of 2*s.* 6*d.* But they did not realise that many of the women were receiving, in addition to their own wages, separation allowances from the Government, or part-time wages from the railway companies in respect of husbands on service. At one time it was quite possible that the negotiations might have broken down on that single point. There were three courses open—to accept the 5*s.* and 2*s.* 6*d.* bonus; to submit to arbitration; or to strike. At the present time a strike was unthinkable, though in peace time he might have favoured it. He knew that a section of the railwaymen had been clamouring for a strike. He advised them "to keep their powder dry," as they would have plenty of opportunities after the war. The union tried to get an increase in wages instead of a bonus; but the companies would not entertain it, because they said any application of that kind would have to be dealt with

by the conciliation boards. The settlement arrived at was the finest ever made in industrial history. The general estimate was that it meant an extra 6,000,000*l.* a year for railway workers. Some day the union would insist that the results of their negotiations should apply to union men only.

Several meetings were held last week in Manchester between representatives of the Cotton Spinners' and Manufacturers' Association and the Northern Counties Textile Trades Federation, to consider an application from the operatives for a 20 per cent. advance in wages.

To this application the employers replied that in view of the loss resulting from the machinery already stopped, the large stocks of cloth held up, made from cotton at abnormally high prices, the restrictions on exports of cloth which may be still further extended, the probable total or partial stoppage of imports of raw cotton, the possible withdrawal or restriction of the use of flour and other cereals required for manufacturing purposes, and the great probability of more men and women being taken out of the industry for the army and navy and for munition work or other national service (all of which matters are beyond the employers' control), and the fact that many mills are at the present time being worked at a loss, they consider the operatives' application most ill-timed. The outlook for the cotton trade is very disquieting, and they fear that they are confronted with a prospect of great commercial depression, and that greater hardships will have to be borne by both employers and operatives. Most of the employers, the reply states, have great difficulty in keeping machinery running, and the industry cannot stand the burden of increased wages. They regret that, for the reasons given, they are unable to accede to the application, and trust it will be withdrawn, as there has never been a greater necessity than exists at present for employers and workpeople to be prepared to make mutual sacrifices in order to maintain the industry as far as possible.

Dealing with the present crisis in the cotton trade, *The Textile Mercury* concludes an article by stating that "employers, not knowing which way to turn to get rid of their increasing stocks, have been heard to aver that it would be much better to stop all work not absolutely essential to the war, and throw money and human energy into winning quickly and decisively."

A paper on "The Education and Training of Apprentices" was read by Mr. H. A. Bennie Gray at a meeting, held last Tuesday, of the Society of British Gas Industries. In this paper the author stated that the age of about fourteen, at which boys generally entered engineering works, was too young an age. To simply raise the age for leaving school would, however, impose a hardship on the majority of parents, unless some allowance towards the upkeep of the child were made by Government. Although from a high socialistic point of view the State should be responsible for the children of the country, still, added Mr. Gray, we had hardly reached that ideal stage yet, nor were we likely to do so for many years to come. The author outlined the system followed by the British Westinghouse Company for educating their apprentices, and pointed out that all the school hours were between 8.30 a.m. and 5.30 p.m.; moreover, almost all the classes were held in the forenoon, before the strain of the day's work commenced to be felt. In any case, only the older lads had their classes in the afternoon. The author laid special emphasis, in the way of contrast, upon the evil of the present system of apprenticeship generally followed, which required that young lads should be roused from bed at any time between 5 and 6 a.m., in the winter months, too—for the continuation classes were held during the winter season—and set to work from that time until dusk. How many boys, he asked, had the energy left to face in the evening a two hours' lecture on mathematics, mechanics or any kindred subject, and of those who had the required energy, how many had also the mental capacity to benefit therefrom when physically tired. The system, he concluded, was wrong from the very foundation, and in this all the members who took part in the discussion completely concurred.

It has come to the notice of the Director-General of National Service that cases have occurred in which an employer has discharged, or has refused to engage, an employee otherwise eligible on the ground that the latter has enrolled as a National Service Volunteer, and that consequently the employer is uncertain as to how long he may be able to retain the man in his employment. The Director-General wishes it to be understood that any employer taking such a step is acting contrary to his wishes and intention; and it may be pointed out, further, that there are no grounds for such action, inasmuch as if and when a National Service Volunteer is called up, in every case the employer will have an opportunity of appealing before a specially constituted tribunal against the man's removal.

THE IRON, STEEL AND ALLIED TRADES FEDERATION.

In a former article, on page 206 *ante*, when analysing the report of H.M. Chief Inspector of Mines to the Home Office, we gave the total yield of pig-iron for the year 1915, obtained from British iron ores, 4,567,351 tons, which, in the words of the Chief Inspector, was more than half the total quantity of pig-iron made in this country in that same year from iron ores of both British and foreign origin. We have now received from Mr. G. C. Lloyd, supervisor, Statistical Bureau, 28, Victoria-street, S.W. 1, the following figures for the production in tons of pig-iron, steel and puddled iron in the United Kingdom, for the year 1916. The figures for 1915 are given for comparison:—

PRODUCTION OF PIG-IRON IN 1916.

District.	Forge.	Foundry.	Basic.	Hematite.	Spiegel Fe-Mn, Fe-Si, &c.	Direct Iron Castings.	Total.
Cleveland	185,564	507,773	817,812	901,971	75,841	8,342	2,497,303
Durham	3,851	4,059	57,115	508,158	26,712	104	599,999
S. and W. Yorks	26,681	46,951	219,706	—	—	—	293,338
Cumberland	—	—	—	663,231	57,292	—	720,523
Lancashire and N. Wales	19,245	19,390	233,652	370,160	121,558	879	764,884
Scotland	72,960	244,035	19,013	708,196	10,442	130	1,144,766
Midlands (Derby, Leicester, Northants and Notts)	316,020	431,324	23,837	160	—	94,270	865,611
Lincolnshire	60,663	11,937	479,182	—	—	50	551,832
S. Wales and Monmouth	—	—	55,137	800,138	—	250	855,525
N. Staffs and Salop	110,608	62,357	165,340	—	—	1,126	339,431
S. Staffs, Worcs and Wilts	103,875	90,998	219,755	—	—	143	414,771
Total in 1916	899,467	1,418,824	2,290,549	4,042,014	291,845	105,284	9,047,983
Total in 1915	1,024,063	1,573,575	2,272,684	3,564,276	255,484	103,577	8,793,659

PRODUCTION OF STEEL IN 1916.

	Bessemer.		Open-hearth.		Electric.		All Other Steel Castings.	Total (excluding Crucible Steel).
	Acid.	Basic	Acid.	Basic.	Ingots.	Castings.		
1916	1,196,153	505,817	4,393,004	3,012,558	30,968	18,288	187,669	9,344,457
1915	821,408	479,816	4,090,752	2,958,968	20,000	2,000	177,071	8,550,015

PRODUCTION OF PUDDLED IRON IN 1916.

1916	951,107
1915	942,906

THE OPTICAL SOCIETY.

A meeting of the Optical Society was held on Thursday, April 12, at Burlington House. The following were elected members of the society:—Mr. W. R. Ashdown, Mr. T. H. Ball, Mr. H. L. Benskin, Mr. J. C. Kirkman, Mr. J. W. Mason, Lieut. G. Mielk, Mr. E. L. Parr, Lieut.-Col. J. V. Ramsden, Mr. J. B. Reiner, Mr. E. L. Vincent, Mr. R. Bigglesworth, Mr. Frank Wood, B.Sc.

A paper on "*Light Filters for Eye Protection*" was given by Mr. L. C. Martin, B.Sc., D.I.C., A.R.C.Sc., in which he stated that characteristics of radiation from particular sources can be obtained by the use of theoretical equations or experimental results. Molten glass at 1,400 deg. C. will have maximum energy at wave length 1.75 μ; a Nernst glower at 2,200 deg. C. will give a maximum about 1.2 μ. The distribution of energy in the solar spectrum is known, also that in the radiation from the sky, &c. The experimental work of Dr. E. E. Martin, Sir W. Crookes and others on the physiological effects of radiation is summarised, and the main features of the action of strong light on the eye are also described. Conclusions are drawn that the first importance of a filter for reducing glare is to reduce the actual luminosity of the transmitted light. The absorption of ultra-violet and infra-red is a desirable precaution under ordinary circumstances, but of the highest importance under special industrial conditions.

Calculation shows that, with or without an optical instrument, the energy passing through a unit cross-sectional area of an eye looking at the sky, or any bright extended area, will be proportional to the area illuminated on the retina. The chief causes of eye-strain when using telescopes, &c., will be excessive contrast on the retina, bad focusing, and possible vibration. The glass of the optical system of a prism binocular absorbs half the possibly harmful ultra-violet rays. A large field of view will be desirable to promote proper adaptation. Filters will be useful to reduce luminosity of the image, and may improve acuity.

For the ultra-violet (0.3 μ—0.4 μ) the Hilger sector spectro-photometer, as used by Professor Howe, is employed, in conjunction with a tungsten arc lamp. For the visible region Sir W. Abney's sector apparatus was used. For the infra-red a mirror apparatus with rock-salt prism calibrated by visible lines, an absorption band due to H_2O, and an emission band due to CO_2, in conjunction with Ruben's results, is employed. Filters tested comprise graded neutral, blue, green, yellow and red glasses, including some due to Sir W. Crookes, also various celluloid and other filters.

In general, the tendency of colouring metallic oxides is to bring the ultra-violet limit of transmission for glasses towards the visible region. Some "neutral" glasses are exceptions, although the intensity of the ultra-violet may be lowered. Glasses containing chromium have a slight absorption band near 0.65 μ. Copper and ferrous iron both give heavy absorption near 1 μ, also cobalt and ferric iron together. Most of the other glasses transmit well in the infra-red; in general the effect of the colouring material seems to diminish with increasing wave-length, and to become indistinguishable at about 4.0 μ. Dyed celluloids appear to have an ultra-violet limit of transmission at 0.29 μ. In the infra-red the dyes caused little absorption after 1.0 μ, but a band at 3.0 μ is shown, which is probably due to the celluloid. Such a band is exhibited by many compounds containing O and H.

Metallic films of gold, silver or platinum are suggested as light filters. They would be useful on account of their comparatively high efficiency in reflecting the infra-red.

The above paper was followed by a communication on "*Accuracy of Observation and Precision in Measurement*," by Dr. G. A. Carse, M.A. He states that certain physical constants are obtained by computation from direct observations. Any observation is liable to error, and a distinction is made between systematic and accidental errors. The mode of obtaining experimentally the possible error of a single observation is given and various methods of expressing it are described. This method is capable of extension to possible errors of indirect observations. In addition, expressions for possible errors of indirect observations are obtained by calculation for a few simple cases.

The programme also included a paper by Mr. S. D. Chalmers, M.A., on "*Some Methods of Analysing Lens Systems*," and a paper by Mr. Charles Cochrane, M.A., B.Sc., on "*A Simple Proof of the Expression for the Focal Power of a Thick Lens.*"

ALUMINIUM COINS.—Nickel coins or tokens of small value are currency in several countries, including the United States, and various alloys of nickel and copper are used. In Germany the 5 pfennig (nominal value a little more than a halfpenny) were made of nickel; they are now withdrawn and replaced by aluminium coins of the same value, each piece weighing about one gramme. These are only war emergency coins, as the nickel is otherwise wanted.

YOKOHAMA HARBOUR.—According to *The London and China Telegraph*, work on the reconstruction of the old pier in Yokohama Harbour is now completed. The work was begun in June, 1912, with an appropriation of 1,200,000 yen, and was to have been completed in 1914, but the work was delayed. Three noticeable improvements have been accomplished by this work—the building of the two pavilions, the dredging of the harbour around the pier, and the provision of a protection work against collisions at the head. The two pavilions, each 60 ft. by 300 ft., which have just been completed, cover 536 *tsubo* on the ground floors and 278 *tsubo* on the second floors. The ground floors will be used for luggage, luggage inspection rooms, and inspectors' headquarters, while the second floors will be used for waiting-rooms for passengers. For the convenience of passengers three automatic bridges have been built with roofs. The depth of water at the pier is 35 ft. at low water and 38 ft. at half-tide, the deepest in the harbour, and the authorities expect that large passenger ships will be able to berth alongside of the pier easily. Under the present plan four large ships will be able to berth at the same time. The length of the pier is 1,662 ft., while the width is 138 ft., so that two ships will easily berth on each side. (1 yen = about 2*s.*; 1 tsubo = 3.95 sq. yards.)

THE PELLIN HARDNESS-TESTING APPARATUS.

OUR readers will remember that on the occasion of the meeting of the Institution of Mechanical Engineers on November 17 of last year Sir Robert Hadfield submitted for inspection a Pellin hardness-testing machine. The meeting had been convened to discuss the report of the Hardness Tests Research Committee, put forward by Dr. T. E. Stanton and Mr. R. G. Batson. (See ENGINEERING, vol. cii, page 550.) We illustrate the Pellin testing machine in the view Fig. 1 on the present page. It is based upon the Brinell dynamic method, and has been designed for the hardness-testing of the different metals used for all industrial purposes. The apparatus is mounted upon a cast-iron base-plate A, on which is fixed a forked spring clamp *v*, which holds the sample to be tested in position. A dovetailed slide G can be raised or lowered so as to vary at will the

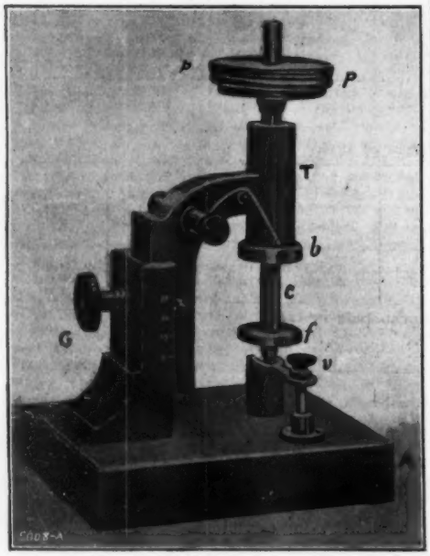
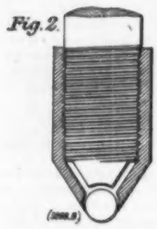


FIG. 1.



height of fall, its displacement being regulated to tenths of a millimetre by the aid of a graduated scale. The slide is provided with an arm having a cylindrical housing T, in which a steel rod C slides freely but without play. The housing T ends in an annular electro-magnet marked *b*, connected to one of the terminals as shown in Fig. 1. The rod C is provided at the top with a disc P, destined to carry a variable series of weights, so as to produce any variation in the ball impression under shock. At the lower part of the rod C is fitted a soft iron plate *f*, the object of which is to cause the adhesion of the whole rod system when the current from a battery is closed on the electro-magnet *b*; the steel ball, 2.5 mm. (0.0984 in.), is held in a holder underneath the soft iron plate *f*. This holder is shown in the sketch Fig. 2. It is easy to cut off the current instantly between *b* and *f* by means of a circuit-breaker fitted to the base-plate A, and the rod, being liberated, acts as a hammer, and by falling upon the specimen under test the ball forms in this an impression, the diameter of which varies according to the hardness of the specimen and the weights with which the disc P has been loaded. The makers of the machine are Messrs. Ph. and F. Pellin, 5, Avenue d'Orléans, Paris, who have kindly supplied us with the above data.

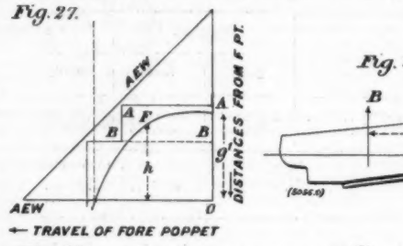
THE SUBMARINE "ISAAC PERAL."—We read in *The Motor Ship*, Seattle, that the submarine "Isaac Peral" is probably the longest submarine ever built in the United States. She is said to have a surface speed of 15.36 knots, or 1.36 knots above the speed of any American submarine now in commission. She has been built by the Fore River Shipbuilding Co., under contract with the Electric Boat Co., for the Spanish Government, and has successfully completed her trials. Under the terms of the contract her builders are not allowed to divulge any details, but according to the *Forum* she is 196 ft. long over all, with a beam of 18½ ft. and a displacement of 700 tons; the cruising radius is 8,000 miles. Her surface-cruising machinery consists of two Nlsseo Diesel engines, built by the New London Ship and Engine Co., Groton, Conn.

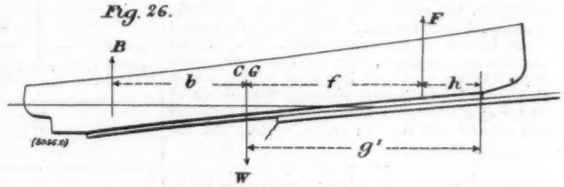
LAUNCHING SHIPS.*

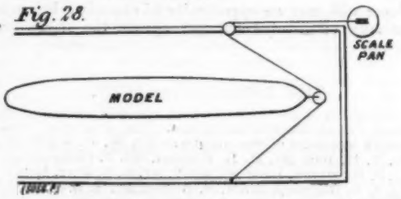
By PERCY A. HILLHOUSE, B.Sc., Member of Council, and WILLIAM H. RIDDLESWORTH, M.Sc., M.Eng.

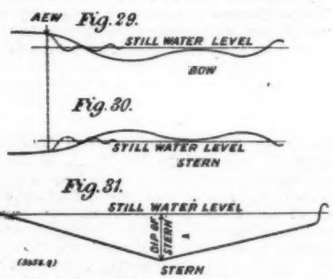
(*Concluded from page* 364.)

Motion of Vessel during Launch.—We do not know that any attempt has yet been made to determine accurately and continously the exact motion of a vessel from start to finish of her launch. Records have been made of velocity and of the maximum dip of bow and stern. The latter are difficult to observe accurately, and are usually referred to the water surface and not to fixed points on shore. But as the water surface is more or less disturbed by the entry of the ship herself, it cannot be said that the maximum immersion of the ship as shown by the rise of the water-line on her side is equal to the maximum depth of her keel below the original still-water level. The relation of the keel to the bed of the river is therefore not accurately known. It is of great importance, however, that the maximum immersions should be known, so that sufficient clearance may be ensured between the after end of the keel and the river-bed and between the forefoot and the lower end of the berth. The theoretical or statical dip of stern can be obtained from the calculation table by plotting draught at A P on a base of travel and measuring the ordinate at the point where the stern begins to rise. But the motion of the vessel and alterations in the water-level may modify the result in some way which it is impossible to predict. The maximum dip of the forefoot, as stated by Mr. Smith in his paper on camber, can be theoretically









obtained by adding to her launching draught the amount which that draught mark is above still water-level at the instant when the fore poppet drops off the after end of the ground-ways. But this again assumes statical conditions, and takes no account of inertia, water resistance, or alteration in water-level. The bow of the vessel just before she drops is travelling in a direction parallel to the slope of the way ends, and has therefore a downward component tending to produce additional dip.

In order to investigate these and similar points of interest we decided, in the case of an important launch, to make a model experiment, reproducing as closely as possible all the essential conditions and recording the whole motion. A large tank was prepared, having to scale the shape and depth of the river, and to represent the ways brass rails were laid, having the proper declivity, camber, and relation to tide-level. The latter point was not essential—any convenient parallel position would have produced the same results. Brass grooved wheels were fixed to the hull at such intervals as to ensure that she would be properly supported throughout her motion, one pair, of course, being placed at the fore edge of the fore poppets and one pair just aft of the centre of gravity to ensure that the vessel would not tip when supported wholly by ways. To determine the minimum number and correct positions of the remaining wheels we were guided by the fact that in any position the vessel is supported partly by buoyancy and partly by a land force supplied by the ways. Let these forces be B and F (Fig. 26), together equal to W, and having equal moments about the vessel's centre of gravity so that B *b* = F *f*, from which the values of *f* and *h* are easily calculable. There must evidently always be a wheel between F and the after end of the ways. On a base line representing travel of fore poppet (Fig. 27) set up a curve representing to the same scale the distance *h* of the land force from the fore poppet, beginning with the value *g'* and becoming zero at the point when the stern rises. Draw also the straight line A E W at 45 deg., representing for any travel the distance of the after end of the ways from the fore poppet. Then there must always be at least one pair of wheels between F and A E W. The aftermost pair of wheels is placed at a distance O A from the fore poppet, O A being slightly greater than *g'*. The horizontal line A A shows the (constant) distance of these wheels from the fore poppet, and this pair will serve to support the vessel until the line A A meets the line A E W, when the wheels pass over the after end of the ways. Shortly before this point is reached draw a vertical line A B, and place a second pair of wheels at the point B slightly nearer to the stern than the then position of the land force. A horizontal line drawn through B shows that this pair of wheels will support the vessel until the stern rises, so that in this case only three pairs of wheels are necessary. The matter could be simplified and the number of wheels reduced to three by fixing a central rail to the model and supporting it by a single wheel fixed to the ground at the after end of the ways. The single rail would have to project a distance E beyond the after perpendicular, and care would have to be taken that its end did not touch the river-bed at the moment of maximum dip aft. This method would reduce friction to a minimum and get rid of the difficulty of getting six or more wheels to bear simultaneously upon the cambered rails. The central rail might also be fixed below water in continuation of the curve of the ground-ways and a single wheel fixed to the ship at A P.

It was important that the model should not only be of correct weight, but that the position of its centre of gravity longitudinally and its moment of inertia for rotation about a horizontal transverse axis through its centre of gravity should be in agreement with those of the actual vessel. Adjustable lead weights were placed on deck and moved to and fro until the latter two conditions were satisfied. The value of the moment of inertia was tested by bifilar suspension, the model being suspended by two long parallel cords equidistant from C.G., its ends pulled sideways in opposite directions and then released, the model being left free to rotate to and fro about a vertical axis through G. If *a* be the distance between the cords, *l* the length of each, and *t* the observed period for a double swing, then the required radius of gyration—

$$K = \frac{a\,t}{4\,\pi}\sqrt{\frac{g}{l}}$$

The velocity of the model when leaving the ways was recorded automatically by means of clockwork and two electrical contacts made by the moving model. The making of the contacts was marked by pens against a uniform pen-marked scale of seconds upon a moving strip of paper, and from the number of seconds from contact to contact the speed of the model was obtained. It was found that the force of gravity was not sufficient to give the required speed, and it became necessary to accelerate the model artificially. This was done by passing a cord from one side of the tank over a horizontal pulley screwed into the stem, then over a second horizontal pulley on the other side of the tank, and finally over a vertical pulley to a scale pan, all as shown in Fig. 28. By varying the load in the scale pan any desired velocity at the way ends could be obtained.

Drags were represented by small bunches of brass chain correctly proportioned as to weight, and attached to the proper positions on the ship's side by cords of such lengths as to bring the drags into play at the correct successive intervals. A curious fact in this connection was that in order to prevent the vessel from being stopped too quickly it was found necessary to lay sheets of smooth glass below the chains, as the friction between the chains and the wood surface representing the ground of the berth was too great.

Weights were proportioned to cubes, and velocities to square roots, of the linear dimensions.

When all was ready and the tank had been filled with water to the height of tide expected, several experiments and adjustments were made until the correct velocity and movement of drags was obtained, and it was found that these results could be correctly repeated as often as desired.

To record the exact motion of the vessel a long drawing-board was placed with one face vertically over the middle line of the launch, and at the fore and after perpendiculars of the model two masts were erected, each carrying a pen which traced an ink line on a sheet of paper fixed to the drawing-board. Different colours were used for bow and stern, and before-launching the

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* Paper read before the Institution of Naval Architects, March 29, 1915.

model a level line was marked on the paper by gauge from the still-water surface.

A preliminary experiment was made by dropping the bow over the ends of the ways without fore and aft movement, except that produced by the wheels in clearing the way ends. As was expected, the amount of dip below the final still-water draught was less than the height of the launch draught mark above water before dropping. The difference represents energy expended in water disturbance, and the ratio of dip to drop was about 0.35.

When the vessel was moving rapidly off the way ends and thereafter both vibrate up and down for some time until the vessel comes to rest.

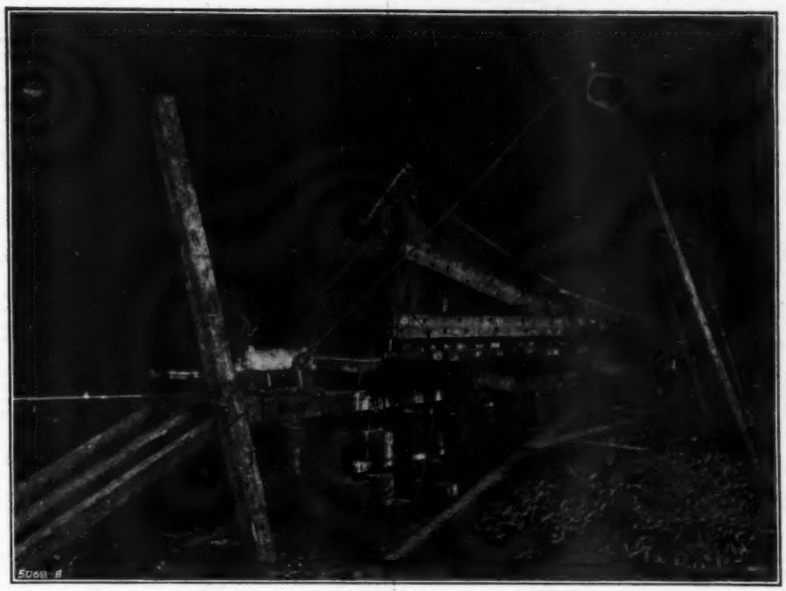


FIG. 32. FORE POPPET FOR A BATTLESHIP.

FIG. 33. FORE POPPET FOR A MERCHANT LINER.

quite another result was recorded, the dip being about 10 per cent. greater than the drop. This is probably due to several causes—the downward component of the motion of the bow, heaping up of a wave aft tending to lift the stern, and the observed fall of the water-level at the way ends when the bow dropped. The final result is of great importance, as it shows that more clearance is required forward than has commonly been considered sufficient.

On page 374, the dotted line, Fig. 29, shows the bow record obtained when the vessel merely dropped off the way ends without previous motion, while the full line shows the path followed during the experimental launch. Fig. 30 gives the corresponding records for the stern. In Fig. 31, which shows nearly the whole path of the stern, the longitudinal scale has been contracted in order to keep the lines within reasonable limits for reproduction. At first both bow and stern lines follow the camber and declivity of the ways, and most of this portion has been omitted from the figures. Then the stern line begins to rise and the bow to fall, the latter movement being due to the fact that the forward pen was some distance forward of the fore poppet wheels about which the model was rotating. It is curious to note how sharp is the angle between the two phases of the movement of the stern and the straightness of its motion after beginning to rise. When the bow drops the stern rises suddenly,

An accurate record of the complete motion of the actual vessel from start to finish would be of great value, and could, we think, be obtained easily and correctly by means of the cinematograph. Two machines would be required, one placed near the stern of the vessel when on the slip, and the other somewhat less than the length of the vessel farther aft. Both would stand at a convenient distance away from the vessel's side, and would have their axes at right angles to the middle line of the berth. In the field of view of each two uprights would be placed as near to the vessel's side as possible, and on each upright a vertical scale of feet would be clearly marked in black and white. On the ship's side would be painted a continuous longitudinal white line crossed by short vertical lines numbered in succession from either end. As the vessel moved the cameras would record continuously the movements of the white line in relation to the two fixed scales on the uprights, and from the known positions of the lines photographed in relation to the ship and to the water-level and ground-ways, the whole motion could be reconstructed. If, in addition, there could be placed in front of each camera a large clock-face with seconds pointer, the two sets of photographs could be correlated and a record of velocities obtained.

In supplement to the illustrations in the paper we give two perspective views of the fore poppet on ship-launching ways. Fig. 32 shows that built up under H.M. battleship Commonwealth, launched in 1903, and Fig. 33 that for the Union-Castle liner Balmoral Castle, also constructed at the works of the Fairfield Shipbuilding and Engineering Company, Limited, Govan, Glasgow.

FOREIGN ENGINEERING PROJECTS.

WE give below a few data on foreign engineering projects, taken from *The Board of Trade Journal*. Fuller information on these projects can be obtained from the Commercial Intelligence Department, Board of Trade, 73, Basinghall-street, London, E.C.

Chili.—The *Diario Oficial*, Santiago, publishes a Decree, dated January 31, granting to Señores Mayer Braun, Jose Montes Thurler and Manuel Iglesias permission to construct a wharf at Puerto Natales for the shipment of cold-storage products. The concession is for a period of nine years. Plans and estimates of the works must be presented by the concessionaires within a period of six months from the date of the Decree. Construction work must be commenced within a year from the date of the approval of the plans and completed within three years.

Peru.—According to *Commerce Reports*, Washington, the cities of Ica, Pisco, and Chincha Alta are to have new water supply and sewerage systems, in accordance with a recent Law promulgated in the official "Peruano." Estimates of the expense of installing the systems in these cities will be made by order of the Executive. To finance this scheme an additional duty of 2 per cent. will, until the completion of the project, be levied on all merchandise imported through the Custom House at Pisco, with the exception of imports in transit to the interior departments of Huancavelica, Ayacucho and Apurimac.

AMERICAN SHIPBUILDING.—We read in *The Marine Journal*, New York, that an unusually large force of men at the Bethlehem Steel Plant, Sparrow's Point, has been concentrated on the manufacture of ship plates and other shipbuilding material in order that the construction of Government work may proceed without delay on this account, with the result that plates and other shipbuilding materials are being manufactured there at a most rapid rate. This, adds our contemporary, is in line with American traditions, and shows that there is an abundance of patriotism in the country, though private citizens are not being given in the daily papers the credit for such which is their due.

PANAMA CANAL RECEIPTS AND EXPENDITURE.—We read in *The Panama Canal Record* that the tolls collected on ships passing through the Canal from the beginning of traffic to January 1, 1917, amounted to $9,461,717.47. During that time the expenses for operation and maintenance were $14,717,072.38. The latter item exceeded the tolls by $5,255,354.91, or over 55 per cent. During the first six months of the current fiscal year the collections of tolls amounted to $2,703,884.68, the cost of operation and maintenance being $3,428,163.23, thus exceeding the tolls by $724,278.55, or less than 27 per cent. In the corresponding period for the preceding fiscal year the cost of operation and maintenance was more than twice the amount of tolls.

DIESEL ENGINE USERS' ASSOCIATION.—At the March meeting of the Diesel Engine Users' Association a set of rules which had been considered and revised by the committee were discussed and agreed to. Mr. John Milton gave some particulars concerning a curious case of failure of the high-pressure air delivery which occurred in a compressor attached to a Diesel engine at High Wycombe. Apparently the trouble was caused by the introduction of a new high-pressure delivery valve, but the actual fault could not be discovered, and it was found necessary to replace the high-pressure delivery valve formerly in use before the air compressor could be got to work again satisfactorily. Mr. Napier Prentice suggested that if the cover of the high-pressure valve were screwed up too tightly the valve spring might be distorted and might hang up. Some particulars were given to the meeting concerning a tar oil which was being introduced on the market as suitable for use in Diesel engines. Several details in connection with the working of Diesel engines were considered and discussed, and Mr. R. W. Lyle drew attention to a blast regulator; this could be fitted between the compressor and the engine, and it rendered the use of a blast bottle unnecessary. It was suggested that the makers might be disposed to offer further information in connection with this development at a subsequent meeting of the association.

BLACKER'S MECHANICAL STRIKER.

THE drawings and photographs on page 378 illustrate a mechanical striker, made by the Mechanical Hammer Company, Limited, of Stalybridge, which is increasingly used now to conserve man-power. It was originally invented for general smithing and is designed to dispense with the services of strikers. Having greater power and precision than a manual worker, it effects a great improvement, apart from the amount saved in actual wages paid. The automatic motion for traversing the head backwards and forwards along the face of the anvil at the will of the smith places the hammer in quite a special category, as it widens the scope of the tool.

In addition to ordinary smithing, the hammer is suitable for making horseshoes, welding tyres, repairing tools, &c. With regard to the first item, the largest size army horseshoes (10 hind, with calkins) can be made by the smith himself without any assistance whatever. The anvil is of a special registered design, having a cut-away portion in the centre as shown. The front of the hammer head is arranged flush with the anvil at the cut-away, and this proves most useful when shouldering. The anvil (which weighs 5 cwt.) stands on a 3-cwt. cast-iron block, a back-to-front adjustment being provided by means of two screws. The machine itself weighs about 11¼ cwt., and the power required to drive is as low as 1 h.p.

Whilst the hammer is in work the belt runs constantly on the fast pulley. This revolves the flywheel, which in its turn oscillates a long slotted lever, to which it is secured by means of a rod passing freely through an eye in the centre of the flywheel, the rod being acted upon by a coiled spring on each side of the eye. The slotted lever is pivoted on a shaft passing through the sides of the frame. The hammer head forms one side of a parallelogram, the remaining sides being the two arms and a travelling nut operated by a square thread screw and secured in position by top and bottom cross-shafts. The cross-shafts in question carry the sleeves in which the arms are bedded. Through the top sleeve a further cross-shaft passes, being secured on the right-hand side to a swinging lever supported by a spring and on the left to another swinging lever held by a connecting rod. The connecting rod is secured to a fork which carries a sliding bowl.

When the hammer head is at rest the connecting rod remains at the pivot of the long slotted lever, and the oscillations of the latter do not affect it. Immediately the treadle is depressed, however, a worm, gearing into a brass segment, moves a quadrant, which in its turn feeds the connecting rod away from the pivot, and the sliding bowl moves along the slot. The oscillations of the slotted lever now begin to affect the connecting rod, which passes the movement on to the lever to which it is attached, and from thence through the front cross-shaft to the hammer head. It will be readily seen that the more the treadle is depressed, the farther is the connecting rod moved away from the pivot, the greater is the movement imparted to it, the greater the swing given to the hammer head, and the heavier the blow. The weight of blow is therefore under the direct and immediate control of the operator. The variation of the weight of blow can also be effected by adjusting the small hook C in Fig. 4, thus raising or lowering the treadle. As mentioned above, the travelling nut forming the fourth side of the parallelogram is fitted to a square thread screw. This screw is revolved clockwise or counter-clockwise by means of steel bevel wheels, which are themselves under the control of a winged foot lever. By the simple depression of this foot lever the head can be travelled to any point on the anvil, and can thus be readily brought to any position for shouldering, heading, cutting-off, &c.

Between the face of the hammer head (at rest) and the anvil there is a distance of 8½ in. to 9 in., so that there is plenty of room for the use of ordinary top and bottom swages and other tools. This distance is maintained by the spring B in Figs. 1 and 4. The hammer is capable of working material up to 2½ in. square efficiently and without undue strain. In order to raise or lower the hammer head all that is necessary is to unlock the rod A in Figs. 1 and 3 and screw or unscrew as desired. As indicated above, this particular hammer is for jobbing work. Certain modifications of the tool are offered for specific jobs.

THE TRADE OF NEW SOUTH WALES.—The oversea imports during December, 1916, were valued at 2,777,193*l.*, and show an increase of 434,486*l.*, or 18.5 per cent., as compared with the corresponding month of 1915. The total for six months was 18,477,039*l.*, an increase of 1,846,402*l.*, or 11.1 per cent., in comparison with the figures for 1915. The oversea exports during December amounted to 4,566,580*l.*, being an increase of 360,301*l.*, or 8.5 per cent., as compared with the corresponding month of 1915. For the six months, July to December, there was a decrease of 3,400,391*l.*, or 14.7 per cent., compared with the same period for 1915.

THE ROYAL METEOROLOGICAL SOCIETY.

THE usual monthly meeting of this society was held on Wednesday, the 18th inst., at the society's rooms, 70, Victoria-street, Westminster, Major H. G. Lyons, D.Sc., F.R.S., President, in the chair. Mr. E. G. Bilham, F.R.Met.Soc., read a paper on "*The Diurnal Variation of Atmospheric Pressure at Benson, Oxon, during* 1915." By means of hourly measurements of traces from the Dines float barograph at Benson Observatory the mean diurnal inequalities for each calendar month of 1915, and for the year, have been obtained and submitted to Fourier analysis. With the exception of the amplitude of the 24-hourly oscillation, the mean results for the year are in good agreement with the normal values for Kew and Oxford. A discussion of the probable errors to which the results are liable leads to the conclusion that the first order term is the most susceptible to casual error due to non-periodic changes of pressure. It is, moreover, well known that this term is largely dependent on local meteorological and geographical conditions, so that considerable fluctuations are to be expected. Comparing the Benson results for individual months with the normal values for Kew, it is found that relatively high values of the diurnal range are associated with high values of the amplitude of the 24-hourly oscillation. The second and third order amplitudes show similar seasonal variations at the two stations.

A paper by Lieutenant C. D. Stewart, R.E., was also read entitled "*Atmospheric Electrical Phenomena during Rain.*" A preliminary investigation has been made into the values of the potential gradient occurring during rain. It is found that maximum values occur in summer and minimum values in winter. The maximum fine weather values occur in winter. The form of the diurnal variation of rain potential gradient is still uncertain, although it appears to have only one oscillation in 24 hours as compared with the double oscillation in fine weather. In most cases rain depresses the potential gradient. Mean depressions have been compared with their corresponding mean hourly rainfalls. The depression was found to be a function of the rate of fall of rain. At Kew the potential gradient is measured directly in volts per metre by taking the potential in volts at a height of a metre. This method gives the time value as obtained from the surface density only where the electrical charge in the air is negligible. This is the case in fine weather, but probably not during rain. The possible errors have been calculated for different potential gradients; in the case of very fine rain the error may be some hundreds of volts per metre.

OIL ENGINES FOR DREDGES.—Oil engines are proving a success on dredges in California waters as well as on the high seas, says the American journal *The Motor Ship*. Recently a fleet of four river dredges owned by the Delta Dredging Co. has been equipped with marine and stationary surface ignition engines made by Fairbanks Morse and Co. The engines are respectively of 20 h.p., 25 h.p., 37½ h.p. and 45 h.p. All the dredges are of the bucket type, and in every way the performance has met with the satisfaction of the owners. With these modern engines the dredges in some cases ran 22 and 23 hours out of the 24. The one longest in service has just finished an eight-month contract, running 23 hours a day continuously. This dredge had a 25-h.p. engine, and used fuel oil costing three cents a gallon.

CANADIAN MOLYBDENUM.—We read in *The Iron Trade Review*, Cleveland, Ohio, that Mr. C. C. Mackenzie, Ottawa, Ontario, recently delivered a lecture before the Royal Canadian Institute on the "Mining and Metallurgical Treatment of Molybdenum." He related the development of what is probably Canada's newest mining branch, and asserted that during the current year Canada will produce more of the mineral than Australia and Norway together. These two countries were heretofore the chief producers of molybdenum. Previous to the outbreak of the war Canada purchased numerous minerals in small quantities from foreign countries, but when hostilities opened she faced the problem of seeking these materials, particularly molybdenum, within her own boundaries. Deposits of the ore were uncovered in various parts of Canada, including British Columbia, Ontario and Quebec. A machine has been devised for treating the ore. The International Molybdenum Company, Orillia, Ontario, the first concern to enter the molybdenum business, intends to build an addition to its plant.

POWER GASES.—In a paper recently read before the Society of Chemical Industry, Mr. W. A. Tookey, M.Inst. Mech.E., states that the composition of a power gas has no material effect on the indicated power of a gas engine. In all cases, whether the fuel used be producer gas of 130 British thermal units per cubic foot, town gas of 500 British thermal units per cubic foot, or oil vapour or mist, the best results will be obtained when the full-load mixture is adjusted to be equivalent to about 45 British thermal units per cubic foot of the cylinder volume, and if the compression be the same, the engine efficiency will also be the same. The usual plan of rating engines at lower outputs when operated with producer gas is attributed to the fact that this gas is less uniform in quality than town gas, and, moreover, owing to the large proportion it forms of the total charge, the engine is more sensitive to such variations. The "stripped" gas which has come into vogue during the war, owing to the extraction of the whole of the benzol from town gas, is equally as efficient as the unstripped gas, provided the charge admitted be adjusted to compensate for the reduced calorific value.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—The output from the Scotch steel works generally, and those in the Clyde district particularly, continues at the high level which has been so distinguishing a feature now for a very considerable time, the demands of the War Office and the Admiralty showing no signs of slacking-off. Nor is there the slightest possibility of any abatement in this demand so long as the present activity on the Western front goes on. Every ton manufactured is rapidly absorbed, the bulk, of course, on Government account in the home markets; for, naturally, less and less is available for export purposes, some small lots for the French and Italian Government alone being permitted. As matters stand, home rates are fixed and unmovable, while those for export are practically nominal—ship plates, 14*l.* 5*s.* per ton and up; and angles, 14*l.* 2*s.* 6*d.* to 14*l.* 5*s.*

Malleable Iron Trade.—No change is to be noted in connection with the malleable iron trade, the constant and ever-increasing activity keeping all the mills running at full speed, both in the steel and the iron departments. With the orders at present in hand there is every probability of a long period of prosperity in front of the malleable iron makers. Government, of course, is still by far the largest consumer, and when its demands have been dealt with very little is available for any other customer, despite the extensive output, so that a certain shortage is apparent in the open market. For "Crown" bars the current quotation is 15*l.* 2*s.* 6*d.* per ton.

Scotch Pig-Iron Trade.—In the pig-iron trade the busiest possible conditions still prevail, the demand for hematite on Government account being so very excessive that none is obtainable otherwise. Large quantities, therefore, are constantly being delivered at the local steel works, the iron works readily absorbing similar quantities of forge quality. Contrary to expectation the advance in the price of Cleveland iron will not affect rates in the West of Scotland, although it is just probable that export may be a trifle firmer in the immediate future. Foundry iron, particularly No. 1, is still very scarce, the supply falling considerably short of the demand.

Wages Claim Settled.—A wages claim made by the Workers' Union, Glasgow, and the Cement Plant Workers, against the Glasgow Steel and Iron Company, Wishaw, has just been settled by Mr. Condie Sandeman, K.C., who has acted as arbiter. To the men workers he has awarded an advance of 9*d.* per shift, to the women workers on time 4½*d.* per shift; and to the women on piece work an advance of 10 per cent. on their present wages—all these to date as from January 1, 1917, and no other to be considered in the meantime. The Workers' Union was represented by Mr. Climie.

JAPANESE SHIPBUILDING ACTIVITY.—Something like a panic, says a Japanese paper, as reported in *The London and China Telegraph*, prevails among various factories and workshops in Yokohama and neighbouring districts because of the fact that the new Asano Shipbuilding Yard at Tsurumi is now absorbing workmen by offering higher wages. It is reported that the new shipbuilding yard is in need of some 10,000 workmen. Altogether four docks will be constructed, and two have already been completed, each dock requiring some 2,500 men. Up to the present the new concern has engaged 2,500 men from Osaka and other districts in Western Japan, and is now endeavouring to secure workmen at various factories in Tokyo and Yokohama. The new shipbuilding yard has recently received from America a quantity of iron materials sufficient for the construction of 13 vessels.

CONSTRUCTION OF MOTOR OMNIBUSES.—The Commissioner of Police of the Metropolis, dealing with the future construction of motor vehicles intended for licensing as motor omnibuses within the metropolitan area, states that the developments of the last six years in the mechanical properties of materials and in designs of structural details lead him to anticipate that it will be possible to construct vehicles to meet the requirements of the public service in London with a lower unladen and gross weight fully laden than 3½ and 6 tons respectively. Since 1909 methods of production of gearing have been developed which will make it practicable to obtain silent and efficient working with lessened total weight of transmission mechanism, and some reduction may be expected in the total weight of power and of transmission mechanism throughout. Attention is also called to the method of inside lighting and of outside advertisements, as it is possible that saving in weight in connection with them might be effected. He deems it necessary, therefore, to give timely notice that new vehicles presented for licensing must be of a type differentiated from existing types by being lighter in weight and with a better form of power transmission. He invites the co-operation of manufacturers in designing and constructing vehicles which can operate in the streets without affording grounds for complaints as to the damage done to residential property by the excessive vibration they cause owing to their weight, and as to the annoyance caused by faulty power transmission. The interests of the community and of the operating companies in this matter are the same, as the introduction of a perfected type of vehicle would greatly popularise the omnibus service, to the benefit of both the operating companies and the public; the Commissioner feels sure that he can in these circumstances rely upon the cordial help of manufacturers. Any representations they may put forward will receive the most careful consideration.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—The only change of note is that collieries now seem to have settled down to something like proper working conditions after the Easter interval, and supplies are coming to hand with greater regularity and with heavier tonnage. There is abnormal pressure for inland deliveries, for the large industrial users have had to call upon their reserve stocks during the last week at the time when the supplies from the pits were none too plentiful. Efforts to replace these have given the market a very strong tone. Best steam hards are particularly in great request, whilst more of the smaller sorts could be used. Gas fuels are going away freely on contract account, but there are no deliveries for anything outside this category. Slacks and cokes are also finding a big inquiry, whilst the house coal problem is not in any way likely to be solved with present tonnage, and the depots and dealers still have an abundance of arrears to contend with. Export is chiefly for Allied powers, and the business for East Coast ports is declining. Quotations:—Best branch handpicked, 20*s.* 6*d.* to 21*s.* 6*d.*; Barnsley and Silkstone, 18*s.* 6*d* to 19*s.* 6*d.*; Derbyshire best brights, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire house coal, 17*s.* to 18*s.*; best large nuts, 16*s.* 6*d.* to 17*s.* 6*d.*; small nuts, 15*s.* 6*d.* to 16*s.* 6*d*; Yorkshire hards, 16*s.* 6*d.* to 17*s.* 6*d.*; Derbyshire hards, 16*s.* to 17*s.*; best slacks, 12*s.* to 13*s.*; seconds, 10*s.* 6*d.* to 11*s.* 6*d.*; and smalls, 7*s.* 6*d.* to 8*s.* 6*d.* per ton at the pit.

Iron and Steel.—The intense activity which prevails in all branches of the Sheffield trades has its counterpart in the general briskness of the material market. Buying is on a large scale for all qualities of raw metals, and if prices were not controlled it is conceivable that they would now be soaring again in much the same way that they did in the early part of last year. Common irons are in very pressing demand, and the call for special brands of hematites is increasing. There is proof, however, that the workshops have got astride the enormous requirements of the Government for certain classes of goods, and that in the next few months there will be a fallling-off in the size of the orders given for this particular work. At present, it is clear, there is no slackening. Local opinion is against the demand of the makers of pig-iron for another advance of 5*s.* per ton on the maximum for their product, and it is not expected that the point will be conceded by the Ministry of Munitions. If it is, then Sheffield firms will have to alter their contracts, for they cannot maintain the present economy of production with base material growing gradually dearer. The exact position in the steel trade is not easily defined. It is patent that the volume of private trade diminishes week by week, and must now be a very small proportion of the whole production for seven days' continuous work. The question of material is the cause of this shrinkage, for the bulk of steel produced in the city is required for war work. It is not now possible to export, without a licence, ordinary crucible cast steel and goods made from it, in addition to the embargo existing with regard to open-hearth steel and steel containing alloys. It is a matter of great difficulty to get the licences for such places as the colonies and Allied countries, so it can be readily understood that not much trade is being done with neutrals. Owing to a recent wages advance the rolling mills and forges in the city have increased their charges for hire work by 15 per cent. Cutlery traders and plate makers are again in difficulties. Open-hearth steel has been unobtainable for some time past for the production of table knives, &c., and the present rapid depletion of stocks points to their speedy exhaustion. Only for Government work can the best quality steel be secured, so that colonial business is being held up, some orders having been on hand for nearly a year. The demand all round upon the cutlery firms is one of the largest they have ever experienced, and particularly are the Government requirements of a heavy character. It is expected that in the course of a few days arrangements will be completed for the allocation to the plate makers of a certain quantity of cupro-nickel scrap, which will enable them to manufacture enough nickel, or German silver, as it was formerly called, to keep together sufficient trade to stave off ruin. This excellent arrangement will enable Sheffield firms to retain a lucrative overseas trade. In the orders which have arrived from foreign and colonial customers are to be numbered the following:—tools, knives, hardware, plate and silver ware, wire rope, machetes, saws, sheep shears, hammers, files and cutlery.

Messrs. Vickers Annual Meeting.—Presiding at the annual meeting of Messrs. Vickers, Limited, yesterday, at Sheffield, Mr. Douglas Vickers, the managing director, stated that the annual meeting synchronised with the fiftieth anniversary of the conversion of the old family private company into a limited one. The only surviving member of the old concern was their present chairman, Mr. Albert Vickers, who was unable to attend on account of ill health. The present Sheffield works were five times the size of the original ones, and the capacity of output in the city alone twenty to thirty times as great. But that was not all. They had developed not only in Sheffield, but all the world over, and they had big interests abroad. Before the war Mr. McKenna descried the firm as a national asset, and that had been fully proved since. He was unable to give details, but there could be no objection to him saying that they had been told by the different departments that their material had done extraordinarily well at the Front. He regretted their inability to present the accounts for the past two years, but emphasised the fact that it was due to the incomplete state of their negotiations with the Government over the excess profit taxation. There were many points to consider, the most important being what relation the cost of special plant for war work should bear to the cost of manufacture, and also the amount of depreciation that should be allowed. The buildings might be useful in after-war trade expansion, but the machines—lathes, presses and boring machines—would probably only be employed to the extent of 5 per cent. The only sound way was to write off the capital expenditure. He was glad to see that this principle was being recognised, for in the new big plants recently put down the Government was bearing the expense and the private firms only managing them. As to the dividend, which was at the rate of 12½ per cent. for the year, he reminded the shareholders that, with income tax at its present level, the dividend was equal to 17½ per cent.

NOTES FROM THE SOUTH-WEST.

Cardiff.—Since the holidays there has been noticeable a firm undertone in the coal market, and prices have had a tendency to harden for almost all classes of semi-bituminous classes. There has been quite a large supply of tonnage—sufficient to keep most of the tips fully employed at the Bute, Penarth and Barry Docks. The shipments, however, were almost exclusively on account of the Admiralty and the Allies, and for ordinary commercial transactions tonnage still remains very scarce. The result is that, notwithstanding a general improvement in the tone of the market, there is but little new business done. Nevertheless the market continues to get firmer, and on Wednesday there was a general advance, and the following were the altered quotations (there being in each case an advance of about 6*d.*):—Second Admiralties, 25*s.* to 25*s.* 6*d.*; best dry's, 22*s.* 6*d.* to 23*s.* 6*d.*; Black Veins (Cardiff shipment), 24*s.* 6*d.* to 25*s.* 6*d.*; Western Valleys, 24*s.* to 25*s.*; second drys, 21*s.* to 22*s.* 6*d.*; other sorts, 21*s.* 6*d.* to 22*s.* 6*d.*; ordinary steams, 23*s.* 6*d.* to 24*s.* In smalls there were also advances, the best being quoted at 15*s.* to 15*s.* 6*d.*; best ordinaries, 13*s.* 6*d.* to 14*s.* 6*d.*; and other sorts, 10*s.* In the bituminous section Black Veins were 24*s.* 6*d.* to 25*s.*; ordinaries (Western Valleys), 23*s.* 6*d.* to 24*s.* 6*d.*; best Eastern Valleys, 22*s.* to 23*s.*, and best smalls, 13*s.* 6*d.* to 14*s.* In sympathy with the Cardiff market a similar improvement was noticeable in the Newport coal market. As already stated, however, but little new business has been transacted during the week, owing entirely to lack of free tonnage.

THE LATE SIR A. J. DURSTON, K.C.B.—We regret to learn, on the eve of going to press, of the death of Sir A. J. Durston, K.C.B., in his 71st year. Sir John had been for many years engineer-in-chief of the Navy until his retirement in 1906, but we must reserve notice of the splendid work he did for the Navy until our next issue.

TRADING WITH THE ENEMY ACT.—The Controller of Foreign Trade has sent us a copy of a new list (No. 24) of additions to the statutory list of firms of enemy nationality or enemy association with whom persons in the United Kingdom are forbidden to trade. Copies of this list can be obtained from the Superintendent of Publications, H.M. Stationery Office, Imperial House, Kingsway, W.C.

THE HEROULT ELECTRIC FURNACE.—Licences have recently been granted by the United States Steel Corporation for five 6-ton Héroult electric furnaces for making special steels, and one 2-ton furnace for making special alloys. The installation of these six furnaces will bring the total of this type operating or contracted for in the United States and Canada to 114. Of these 30 have been licensed since January 1 of the present year.

GERMAN WAR PROFITS.—The large Gelsenkirchen Mining Company, whose present share capital amounts to 188,000,000 marks, has declared a dividend for last year of 12 per cent., against 8 per cent. for the preceding year. The gross profits amount to 53,003,031 marks, against 41,855,860 marks for 1915, but it should be remarked that for the first time general expenses, such as interest, welfare expenditure, insurance, &c., have been deducted prior to the gross profits being arrived at, and the same probably applies to the war profit tax reserve. Writings-off amount to 22,024,680 marks, and a sum of 2,500,000 marks is reserved for the transition to peace work. During 1916 a sum of 9,476,452 marks has been expended upon new installations.—The Upper Silesian Railway Supply Company pays a dividend of 15 per cent. for last year, against 10 per cent. for 1915, 2 per cent. for 1914, and as little as 1½ per cent. for 1908 and 1909. The writings-off for 1916 amount to 9,428,966 marks, against 6,008,506 marks for 1915 and 3,604,165 marks for 1914. In October, 1916, the orders in hand represented an aggregate sum of 100,000,000 marks, against 28,000,000 marks in May, 1915, and 10,000,000 marks in May, 1914, and the company has orders in hand at remunerative prices for a long time to come.—The Consolidation Mining Company, Gelsenkirchen, pays a dividend of 22 per cent. for last year against a dividend of 18 per cent. for the preceding year. The Halle Machine Company pays a dividend of 25 per cent. for last year, and is expected to be fully employed for a long time to come.—The Sachsenwerk (light and power) pays a dividend of 20 per cent. for last year, against 18 per cent. for the previous year, but instead of cash the shareholders receive new shares for the amount of the dividend; the shareholders will have an opportunity of disposing of their dividend shares to a bank syndicate at fixed rates. Prospects are stated to be favourable.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Great firmness continues to characterise Cleveland pig-iron, notwithstanding the rather plentiful supply. Inquiries both on home and foreign account are numerous, and business is not only on a fairly good scale, but there are unmistakable indications of continued activity. Under existing conditions buyers are not much inclined to commit themselves ahead to any extent, and business is mostly confined to transactions to meet early needs, but a few forward contracts are being made, and in one or two cases negotiations are proceeding for arrangements for supplies over the next six months, such contracts being subject to any official changes in quotations. Improvement in the truck situation has much facilitated distribution, and good deliveries to home consumers are now being carried out with regularity. For home use, No. 3, No. 4 foundry, and No. 4 forge all stand at 92*s.* 6*d.*, and No. 1 is 96*s.* 6*d.* Licences for shipment to France and Italy are being issued, and cargoes are being dispatched as expeditiously as circumstances permit. Export prices have advanced. No. 3 is now 102*s.* 6*d.*, No. 4 foundry 101*s.* 6*d.*, and No. 4 forge 99*s.* 6*d.* The stock of Cleveland pig-iron in the public warrant stores stands at 2,117 tons, all of which but 6 tons of iron deliverable as standard is No. 3 quality.

Hematite Iron.—All legitimate home requirements continue to be met. The general opinion prevails that the authorities will shortly sanction a rise. As there is general disinclination to accept orders at the rates that have ruled for some time past, market quotations are largely nominal. Nos. 1, 2 and 3 are 122*s.* 6*d.* for home consumption, 137*s.* 6*d.* for shipment to France, and 142*s.* 6*d.* for export to Italy.

Coke.—There is a very ample supply of coke, but continued good demand upholds quotations. Thus average blast-furnace sorts still command the fixed maximum of 28*s.* at the ovens, and the limitation figure of 30*s.* 6*d.* continues to rule for qualities low in phosphorus.

Manufactured Iron and Steel.—As regards finished iron and steel, manufacturers continue working at high pressure, and are still increasing their output. Notwithstanding pressure for delivery of other descriptions, production of material for mercantile shipbuilding is growing, and has now assumed very considerable proportions. The following are among the principal quotations for home consumption:—Common iron bars, 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; double best bars, 14*l.* 10*s.*; treble best bars, 14*l.* 17*s.* 6*d.*; iron ship plates, 13*l.* 10*s.* to 14*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 17*l.* 10*s.* to 18*l.* 10*s.*; steel bars (no test), 14*l.* 10*s.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel ship rivets, 19*l.* to 20*l.*; steel boiler plates, 12*l.* 10*s.*; steel strip, 17*l.*; steel hoops, 17*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; heavy steel rails, 10*l.* 17*s.* 6*d.*; packing iron and steel (parallel), 13*l.*; and packing iron (tapered), 15*l.* 5*s.*

Cleveland Ironstone Miners' Wages.—The Cleveland Ironstone Mineowners and the Executive of the Cleveland Miners' met at Middlesbrough this week and agreed that the wages of Cleveland miners be increased by 0.75 (¾ of 1) per cent. for the next three months. The question of war bonus was adjourned for a week.

THE METRIC SYSTEM: ERRATUM.—In Mr. Sutton's letter in our last issue, page 359, middle column, the words "42 cm. howitzer" were printed as "4.2 cm. howitzer." The dot over an *i* in the line below in Mr. Sutton's manuscript was mistaken for a decimal point as it happened to be high up. This is one of the chances which occur with a decimal system, whether it be British or metric.

INDUSTRIAL DEVELOPMENT IN FINLAND.—Although no doubt on a small scale, the unwonted activity which prevails within Sweden, Denmark and Norway also makes itself felt in Finland. Thus a mining company has recently been started, with the option of a capital not exceeding 10,000,000 Finnish marks. Another company formed for the purpose of working some large limestone deposits has a maximum limit of 1,000,000 Finnish marks.

STELLITE.—According to a report to the Canadian Mining Institute of a special committee on metal industries "Stellite" is composed of cobalt, chromium and tungsten without any iron. It is claimed that this metal is to high-speed steel what high-speed steel is to ordinary carbon steel; that is, that it will allow of increasing the rate of cutting on the lathe from 20 per cent. to 50 per cent., and minimises the time consumed in sharpening tools."

NEW SHIPBUILDING AND MARINE ENGINEERING WORKS REQUIRED.—The Ministry of Shipping forwards the following for publication:—The Shipping Controller would be glad to hear from any engineering firms in the United Kingdom not usually engaged in building marine engines who would undertake this class of work. They should state their possibilities. Further, the Controller would be glad to know of any schemes for establishing new shipbuilding yards in any parts of the country. Letters should be addressed Shipping Controller, St. James's Park, London.

BLACKER'S MECHANICAL STRIKER.

CONSTRUCTED BY THE MECHANICAL HAMMER COMPANY, LIMITED, STALYBRIDGE.

(*For Description, see Page* 376.)

Fig. 1.

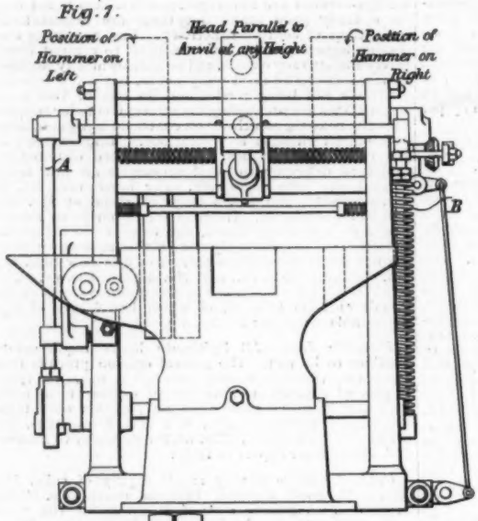


Fig. 2

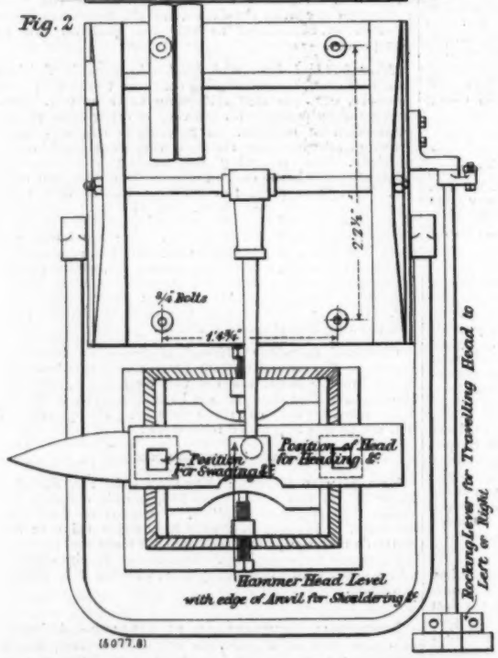

2'2¾"
¾ Bolts
1'6¾"
Position for Swaging &c.
Position of Head for Heading &c.
Hammer Head Level with edge of Anvil for Shouldering &c.
Rocking Lever for Travelling Head to Left or Right
(5077.B)

Fig. 3.

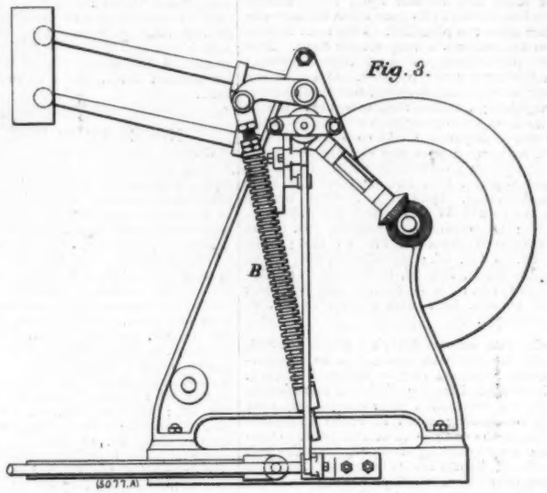
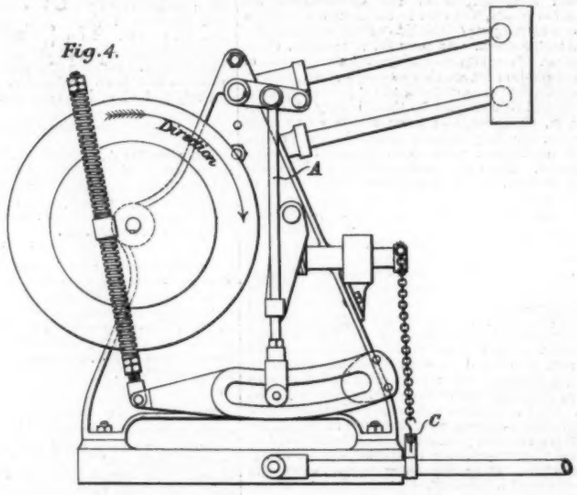


Fig. 4.



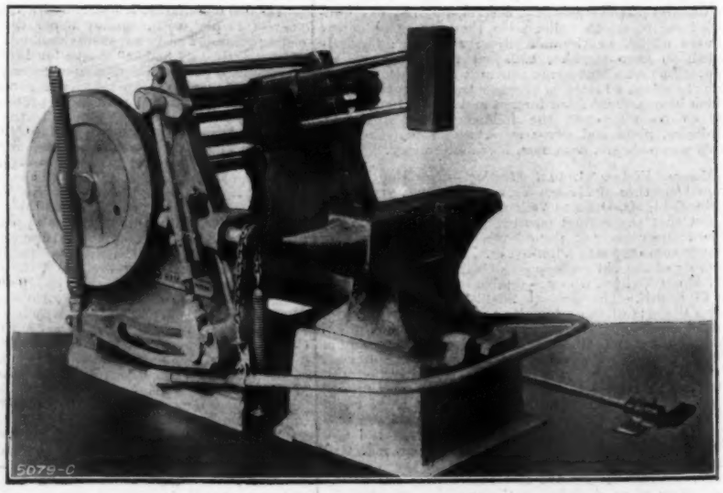


FIG. 5.

PETROLEUM FROM ASSAM.—According to a paper read before the Institution of Petroleum Specialists on the 17th inst. by Mr. H. S. Maclean Jack, the crude petroleum in Assam is found in intermittent deposits situated in loose sands. On first striking the oil the well usually flows with a good deal of force, and it is not until the well has reached a mature age that pumping is necessary. The pure crude is 0.856 specific gravity, appears of a very dark brown, almost black, colour by reflected light, without the fluorescent greenish tint common to many American oils. By transmitted light at 84 deg. F. the colour is warm sienna, and the oil is quite transparent, and free from suspended particles of extraneous insoluble matter. The oil is perfectly fluid at 82 deg. F., but at 81 deg. F. crystals of paraffin begin to form and settle. These crystals are separate and defined; they do not agglomerate into a solid cake, but can be easily diffused through the oil by slight agitation. At 77 deg. F. the oil loses fluidity and becomes semi-solid. In the boiler stills the distillation is continuous. From the first still crude benzene is taken off, about 750 deg. to 770 deg.; from the second still intermediate kerosene, and from the third the bulk of the ordinary kerosene. The residue is distilled to dryness in pot stills. The crude benzene obtained from the boiler stills is redistilled in closed steam coils, and two qualities of petroleum spirit are produced, having specific gravities of 0.710 and 0.750. The amount of lubricating and other heavy oils refined is not large enough to merit attention, but paraffin wax is one of the most important constituents of Assam petroleum, which resembles in this respect most of the Eastern oils. It is a hard wax of very high melting-point, and the percentage in the crude is considerable. The melting-point adopted as a standard is 135 deg. F., but during the greater part of the year the difficulty is to obtain the softer waxes to blend with the harder and get this average.

WOMEN WAR MUNITION WORKERS.

(*For Description, see Page 372.*)

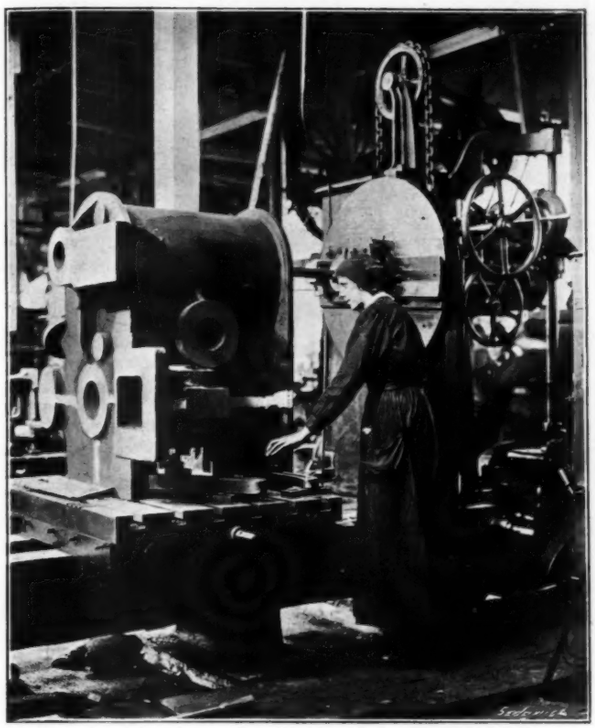


Fig. 1. Machining a Cylinder.

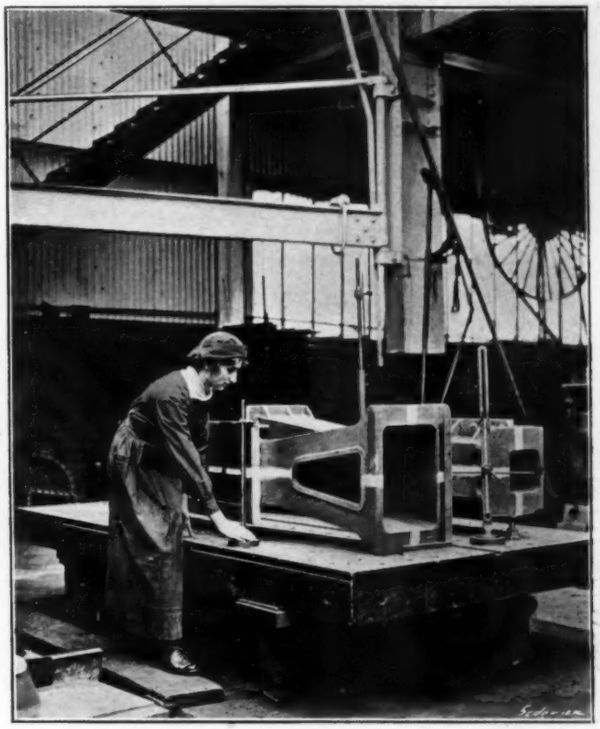


Fig. 2. Marking-Off Engine Columns at Surface Table.

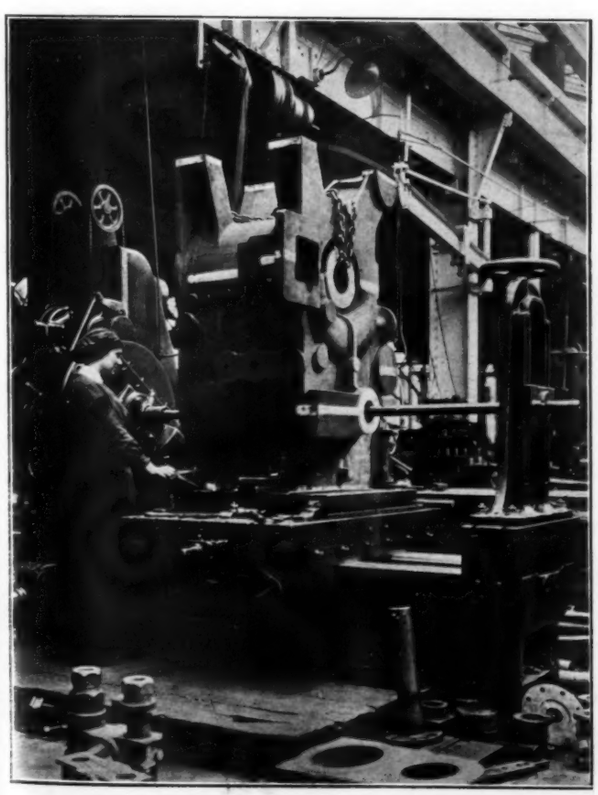


Fig. 3. Boring a Cylinder.

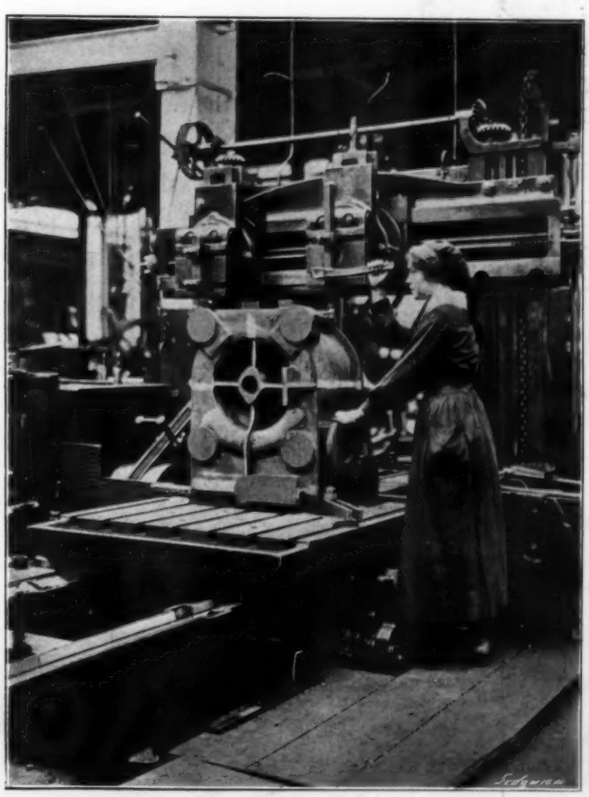


Fig. 4. Planing a Cylinder.

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WOMEN WAR MUNITION WORKERS.

(*For Description, see Page* 372.)

FIG. 5. CORE-MAKING IN A FOUNDRY.

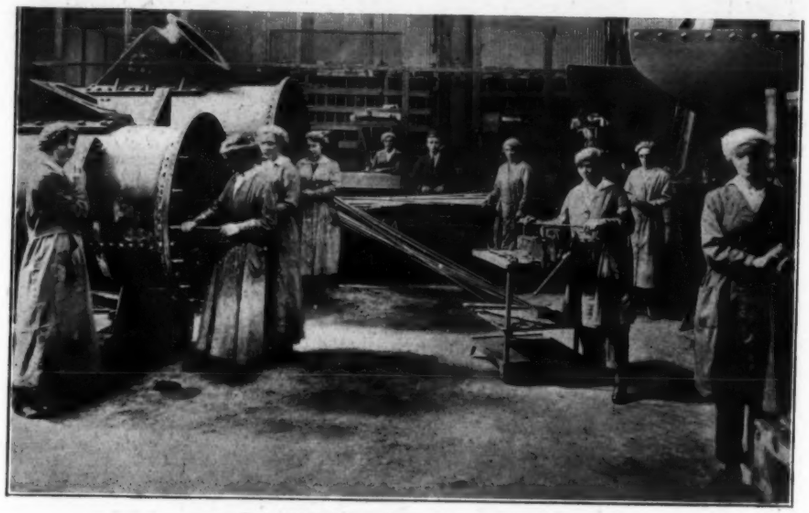

FIG. 6. TUBING A MARINE ENGINE CONDENSER.

FIG. 7. FINAL TURNING OF RIBS OF A ROTARY AERO-ENGINE CYLINDER.

FIG. 8. MILLING THE TOP OF AN AERO-ENGINE CYLINDER.

WOMEN WAR MUNITION WORKERS.

(*For Description, see Page* 372.)

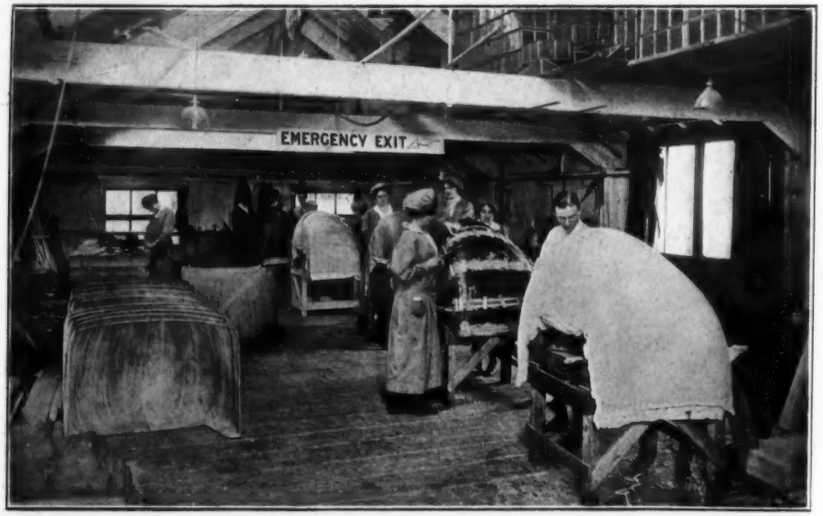

FIG. 9. CONSTRUCTING AEROPLANE NOSES.

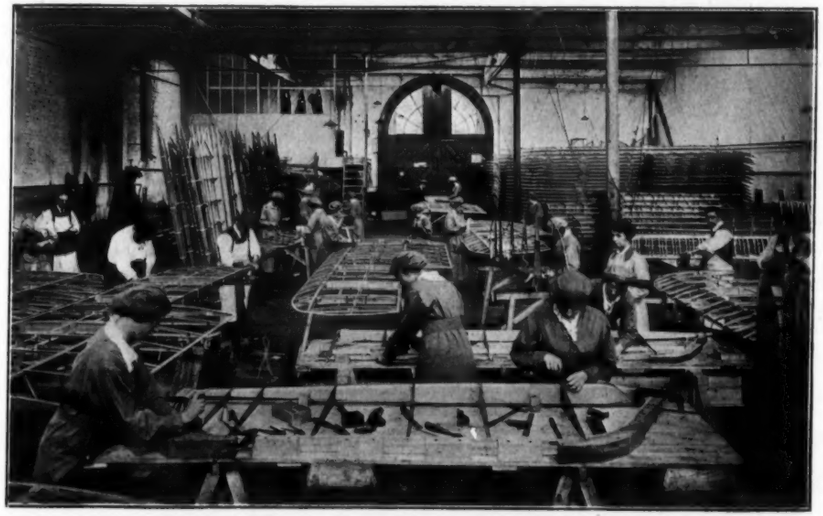

FIG. 10. BUILDING WINGS OF AEROPLANES.

FIG. 11. DIVIDING PEARL DIALS FOR PRISMATIC COMPASSES.

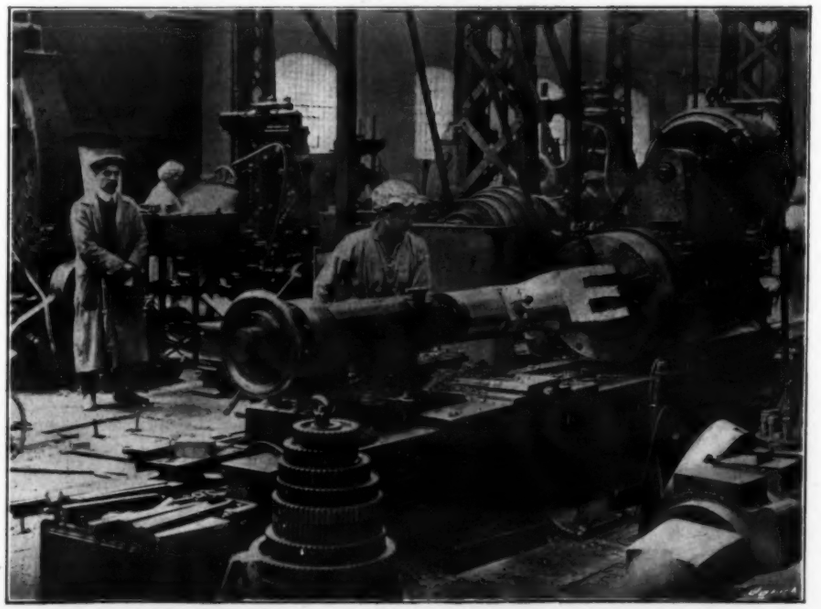

FIG. 12. ROUGH TURNING JACKET FORGING FOR HOWITZER.

WOMEN WAR MUNITION WORKERS.

(*For Description, see Page* 372.)

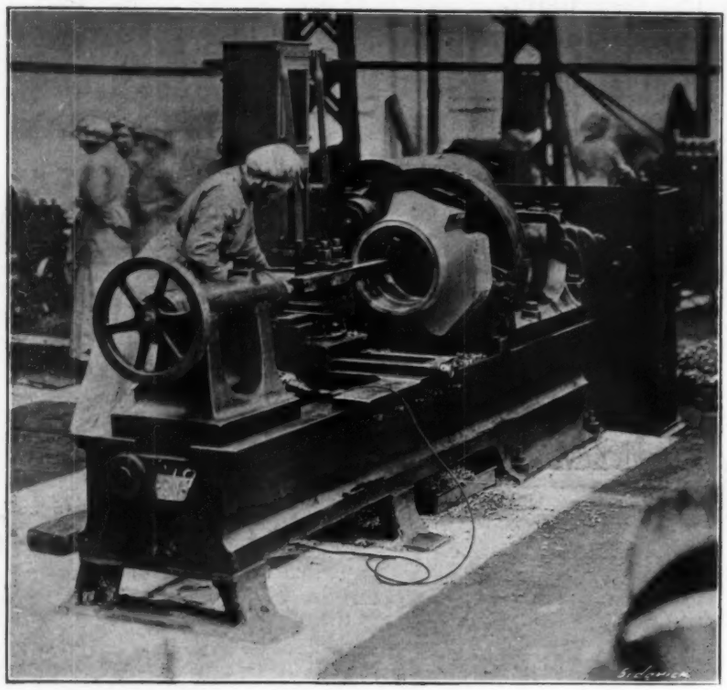

Fig. 13. Turning, Boring and Screwing Breech Rings for Howitzer.

Fig. 14. Slotting the Profile of Breech Ring of Howitzer.

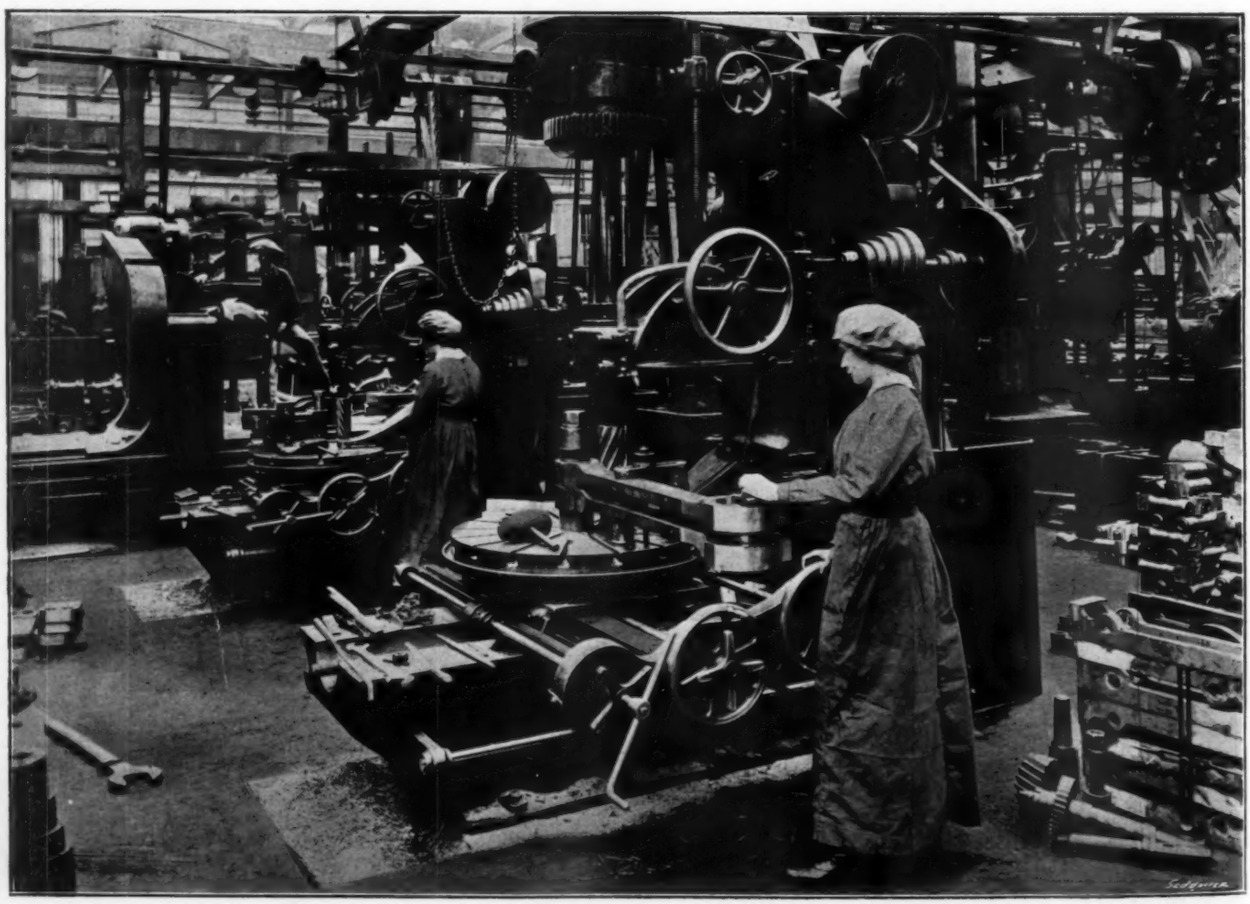

Fig. 15. Milling Coupling Rods and Spring Links for a Locomotive.

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The charge for advertisements is three shillings for the first four lines or under, and eightpence for each additional line. The line averages seven words. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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When foreign subscriptions are sent by Post-Office Orders, advice should be sent to the Publisher.

Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C. 2.

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We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3883 and 8596 GERRARD.

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NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, April 20, at 6 p.m., at the Institution of Civil Engineers, Great George Street, Westminster. The President, Mr. Michael Longridge, will deliver his address.

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, April 25, at 8 p.m. The annual general meeting of the session will be held at the Royal Institution, Colquitt Street.

THE ROYAL SOCIETY OF ARTS.—Wednesday, April 25. A paper on "Flour and Bread" will be read by Sir Francis Fox, M.Inst.C.E. Captain Charles Bathurst, M.P., Parliamentary Secretary, Ministry of Food, will preside. The chair will be taken at 4.30 p.m.

THE ROYAL SANITARY INSTITUTE.—Wednesday, April 25, at 5.30 p.m. Lecture by Mr. M. S. Pembrey, M.A., M.D., Lecturer on Physiology, Guy's Hospital, on "The Restricted Supply of Food; its Relation to Health and Efficiency."

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, April 26, at 6 p.m., at the Institution of Civil Engineers, Great George Street, Westminster, S.W. "High-Tension Overhead Transmission Lines," by Mr. G. V. Twiss, Associate Member.

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, April 27, at 7.30 p.m., in the Lecture Theatre of the Literary and Philosophical Society, Newcastle-upon-Tyne. The following paper will be read and, time permitting, discussed:—"A Method of Finding the Indicated Horse-Power for Steamships," by Mr. R. W. de Rusett, Member.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, April 27, at 5.30 p.m. A discourse will be delivered by Mr. J. Dundas Grant, M.D., M.A., F.R.C.S. The subject is "The Organs of Hearing in Relation to War." Afternoon lectures next week at 3 p.m. Tuesday, April 24. Professor C. R. Beazley, D.Litt., on "Russian Development—the Rise of Moscow" (Lecture II). Thursday, April 26. Professor H. S. Foxwell, M.A., F.B.A., on "Industrial Finance after the War—its Financial Needs: How they can best be met" (Lecture II). Saturday, April 28. Professor G. H. Bryan, Sc.D., F.R.S., on "Principles of Aerial Navigation" (Lecture II).

THE INSTITUTION OF LOCOMOTIVE ENGINEERS, LONDON, INCORPORATED.—Saturday, April 28, at 2.30 p.m., at Caxton Hall, Westminster. A paper will be read by Mr. J. Rodgers, Member, of the Locomotive Department, London, Brighton and South Coast Railway, on "Locomotive Design."

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal from 6d. to 8d. per copy. This increase dated from and included the issue of Friday, March 16. The change will not apply to unexpired subscriptions.

ENGINEERING.

FRIDAY, APRIL 20, 1917.

THE NATIONALISATION OF RAILWAYS.

No doubt a vigorous effort will be made by a certain school of politicians to nationalise the railways on the conclusion of peace. In view, however, of the ineptitude which the war in its earlier stages made manifest in nearly every old-established Department of the Government, this policy is, perhaps, less likely than for many years past to receive favourable consideration from Parliament. The advocates of nationalisation point to the efficiency with which our railways have been operated since they were taken over by the Government. Of course the more reputable of them are careful not to assert definitely that the wonderful records established during this period are the direct result of official interference, but they are at least equally solicitous so to word any statement they may make on the subject as to convey this impression to the uninformed, and, indeed, to impose the belief that these achievements are merely an earnest of the good to accrue from complete State ownership and control. Political memories are proverbially short, a fact which is fortunate for the politicians, but similar prophecies as to efficiency of management and as to vast contributions to the Treasury were made when the telegraphs were acquired nearly forty years ago, and the actual results are on record.

As a matter of fact, although our railways are at present under Government control, the general direction of affairs has remained under the control of the directors, and the actual working management has been retained in the hands of the companies' officials, who have had to "make good" under competitive conditions, and not in the easy, if complicated, routine of a Government office. If the boards of directors had done no more than select their chief officials they would have fully justified their existence. From the ranks of the officials thus selected the Government has drawn many men who are now charged with the direction of a number of other important national services having little or no connection with railways, and the results have shown the high value of the technical knowledge and administrative ability thus rendered available.

Government officials are primarily loyal to their Department, and only secondarily to the State they are supposed to serve. It is in fact a tradition of the services that every effort must be made to screen from publicity all blunders, whether due to an incompetent chief or to a comparatively subordinate official. Moreover, there is in all Departments a great reluctance to welcome into the service experts trained elsewhere. In one case, in which the course could no longer be avoided, the engineer appointed was frankly told by his new chief that his presence was highly unwelcome, as he resented having a subordinate who knew more than he did. Probably this tradition has been, at least in part, responsible for the extraordinary methods adopted for selecting inspectors to supervise contracts. As the scandal in the Army Clothing Department showed, the main reliance is placed on purely clerical checks, an army of different grades in the official hierarchy checking off figures received from those below them and passing them on for rechecking by their official clerical superiors. The actual inspector is, however, often a cheap and ignorant man. Thus ex-gardeners have been appointed steel inspectors, whilst the acceptance or rejection of shells has, in certain instances, been made to depend on such technical qualifications as a jockey or a stableman may manage to pick up in the course of a few days' training.

Railway companies have, however, always realised that no multiplication of the clerical staff can compensate for the lack of technical qualification elsewhere, and the nation has benefited accordingly during this time, in which record traffics have had to be conducted with greatly diminished staffs and with material which it has not been possible to maintain at the normal standard of excellence. Since, however, advocates of nationalisation profess a creed rather than a policy, it is little likely that the more extreme of them will benefit by such object lessons as the foregoing, and it is of some interest to note the crudity of some of the ideas brought forward. A correspondent of the *Railway Herald*, writing last September, advocated the establishment of a system in which all the higher railway officials, whether technical or clerical, should be elected by a popular vote of the railwaymen, and for a period of three years only, being ineligible for re-election.

At the recent Trade Union Conference in Glasgow again the demand was made for the immediate transfer of the railways to the State at their real value, it being apparently considered that this is represented by the present market price of the stocks. As a matter of fact, the market price is fair only between a willing seller and a willing purchaser, and may be either much below or much above the true intrinsic value. A salted gold mine may have temporarily a high quotation on the Stock Exchange and yet prove a very sorry investment. Again, in the early days of the telephone, stock was sold by many who were discouraged at the slow progress made towards financial success, for what the shares would fetch. It would have been most unfair to have bought up compulsorily, on this basis, the holdings of those who, with faith and vision, were convinced of ultimate success. There is, in fact, no more difficult problem than that of determining the fair value of any undertaking which is to be compulsorily acquired. It is sometimes suggested that the cost of replacement represents this, but in the nature of things an estimate thus formed can have reference to material values only, which seldom, if ever, constitute the whole value of any undertaking, and are often much below it. The value of a prosperous newspaper, for example, is far from represented by its material equipment of offices, paper, machinery and plant. The value of the

"intangibles" in this case far exceeds that of all the material property, and in all successful business enterprises these intangible values form a substantial fraction of the whole. In fact the United States Interstate Commerce Commission has recognised that capital spent even in fruitless experiments may constitute a fair claim for inclusion in the valuation of railway property. Experiments are essential to progress, and only a few can succeed. Even negative results have, however, their value in narrowing the field for further experiment. Directly or indirectly the community must pay for these failures, or stagnation will ensue, as it did in this country when the singularly short-sighted electric lighting Act of Mr. Chamberlain robbed us of the lead in this department of industrial enterprise.

But two advantages may fairly be claimed for State ownership. Whilst, as instanced in France, Australia and Italy, such ownership does not preclude the possibility of unreasonable strikes by railwaymen, the situation can be dealt with more forcibly and more promptly than if the lines are under private direction and control. It is to be hoped, however, that the new spirit which has arisen during the war may check the previously increasing tendency of public utility employees to attempt to exploit for their own benefit the community at large. A second advantage lies in the greater readiness with which freights can be lowered to meet certain emergencies. An instance was provided some few years ago in South Africa. Here one of the parties to a shipping dispute concluded contracts for Natal coal on the basis that these collieries should not furnish bunker coal to Cape Town save at prohibitive rates. The move was checkmated, not by the process of declaring such contracts void as being in restraint of trade, but by the State railways agreeing to haul coal from the Transvaal to Cape Town at almost nominal rates. On the other hand, however, the drawbacks to State railways are very great, although their full force would, as in the case of the telegraphs, hardly appear in the earlier years, whilst the old officials appointed by the companies still retained their posts. Sooner or later, however, the reluctance to pay for ability would make itself felt. The number of posts in which initiative is now possible would be steadily and continuously reduced, and the continued efficiency of the service would, as in the case of other State lines, become dependent on the possibility of appropriating the experience and ideas of company-owned lines in other countries. It is at least remarkable that State railways the world over have not, so far as we are aware, been responsible for a single important improvement in railway equipment or operation. State telephone services are in a similar case, America, not Germany, having in pre-war times been the Mecca of those who wished to learn whatever was best in telephone practice.

COAL GAS FOR INDUSTRIAL PURPOSES.

AN interesting exhibition was opened last Monday, the 16th inst., by Mr. D. Milne Watson, managing director of the Gas Light and Coke Company, at the special demonstration shop erected by that company some time ago at their city depot, 146, Goswell-road, E.C. The object of this demonstration shop, Mr. Watson stated, was to afford manufacturers an opportunity to inspect all kinds of gas-heated appliances for use in the multifarious industrial processes in which heat was employed, and to make experiments in the application of gas heating to their own particular requirements. The shop contains a number of furnaces by Messrs. John Wright and Co., Aston, Birmingham, many of which are working for demonstrations of metal melting, hardening of high-speed steel, annealing, &c. Demonstrations will be given daily until Saturday, May 12, and all interested business men are invited to attend them. Mr. Watson laid emphasis upon the advantages of using gas in the metallurgical operations referred to; it was cleaner and cheaper than the rival means and took up a limited amount of space. Great credit was due to Messrs. Wright and to other firms for the improvements they had carried out in the construction of gas-fired furnaces, and his company, the speaker added, greatly appreciated their efforts.

After a few words by Mr. H. James Yates, chairman of Messrs. John Wright and Co., thanking Mr. Watson for his kind words of appreciation, Mr. S. N. Brayshaw expressed the opinion that gas, far from having been killed by electricity, as had been frequently stated, was now stronger than ever. He referred to the last meeting of the Institute of Metals, in the course of which several papers were given on the subject of metal melting. One of these papers, contributed by Mr. W. J. Hocking, on "Metal Melting at the Royal Mint" (see page 309 *ante*), stood out prominently. The gas-furnace plant at the Royal Mint was not an experimental plant; it had melted about 10,000 tons of metal in the last five years. The paper gave the cost of working with gaseous fuel and also that of the preceding period with coke fuel; gas had cheapened the production all round. Mr. Brayshaw then alluded briefly to the various furnaces in view and in operation on the premises, and to the range of work to which his furnaces were applicable, adding that those designed for metallurgical purposes had duly kept step with the progress made in metallurgy in regard to the critical points, the correct observing of which was absolutely essential for obtaining the desired metal texture. The high temperatures required in a number of metallurgical operations were invariably obtained in the furnaces with gas supplied direct from the main and an air pressure which never exceeded a maximum of 5 in. of water; this meant that practically no power was required for air compression, a simple fan running at a high speed being fully sufficient. Any atmosphere, whether oxidising, reducing or neutral, could be produced at any required point inside the furnace.

Among the furnaces exhibited we may mention a 600-lb. Wright lip-axis, tilting, gas-fired crucible brass-melting furnace, in which the pouring-point remains constant throughout the whole tilting movement. The metal is poured into a short runner carried under the lip. The trunnions round which the furnace turns are fixed on an axis adjacent to the pouring-lip of the crucible, the bottom part of the furnace being raised by chains, one on each side, operated by means of a hand-wheel geared down to a shaft carrying machine-cut chain-wheels. The ends of the chains are fastened to the bottom of the furnace body, and the weight of the latter is balanced by a suitable counterweight, so that when the hand-wheel is turned the furnace is tilted on its axis without the pouring-point being shifted and with the minimum of effort on the part of the operator. The furnace is provided with a preheater and cover, which are swung on one side for pouring by means of a lever and cam device. The furnace bottom is fitted with doors, through which, in the case of crucible breakage, the spilled metal falls into a suitable receptacle, whence it can be removed. Either chain is capable of taking the full load. The body of the furnace is of mild steel. Close to this is a 100-lb. central-axis crucible tilting furnace for melting copper, brass, aluminium, &c., and a Wright "Lopress Regenerative" annealing furnace; a 100-lb. and a 160-lb. pit-type crucible furnace, each provided with a cast-iron and firebrick cover, fitted on wheels running on rails for clearing the crucible opening. Another interesting item is a Wright gas-heated nosing furnace, for heating the open ends of shell bodies before bottling-in the ends. Other items are low-pressure case-hardening furnaces and furnaces for treating high-speed steel, all of which can be tested with the visitors' own materials.

Another event of interest which took place this week in connection with the utilisation of gas was the induction, on Tuesday last, of Sir Robert Hadfield, F.R.S., as President of the Society of British Gas Industries. In the course of his address Sir Robert said that, owing to the serious demand made upon his time in connection with war work, he could only speak briefly for the present. He hoped that later, when he had more time at his disposal, he would be able to give a longer address. He would not, however, let the opportunity pass without thanking Messrs. Fletcher, Russell and Co. for the help they gave him, some thirty-five years ago, in enabling him to turn for the first time his attention, in an experimental way, to the melting of steel and its wonderful alloys, a branch of work with which he had ever since been associated. He expressed the opinion that there was no section of the community which was rendering more help to fight the war to a successful conclusion than the British gas industries. This applied both to the production of gas for heating and other purposes and to the production of coal-tar derivatives, which furnished the basis for high explosives. He could not give the home output of these latter products, but he gave the American figures for by-product recovery (see page 351 *ante*), and added that both directly and indirectly this country had been of benefit to the United States, as, owing to our demands for these products, we had gradually brought America to the point of being able to help us to meet our enormous requirements. We had, further, been the means of enabling the United States to obtain a vast addition to their military resources and industrial preparedness, which we were thankful we could now say would be usefully applied in our common struggle against barbarism.

Sir Robert then added that his works in Sheffield were now using gas for heating and other metallurgical purposes at the rate of some 500,000,000 cub. ft. per annum. His works, like many other armament firms, found gas fuel of supreme importance in the manufacture of munitions of all kinds; therefore, he repeated, the value of the gas industries to the nation at the present time was of immense importance. Sir Robert also added that the total quantity of gas made in the year before the war (1913) in the United Kingdom had been stated to be 160,000,000 units of thousand cub. ft., requiring some 17,000,000 tons of coal. The average production of coal gas per ton of coal used was about 11,538 cub. ft. In addition to the above there was a total of about 25,000,000 thousand cub. ft. of carburetted water gas produced. He referred to this because an expert told him that this was equivalent to a saving of 2,000,000 tons of gas coal, reducing thereby the production of gas coke for the year by 1,500,000 tons. This was an immense help to the gas undertaking, for the reason that there was generally a surplus production of gas coke, which was not easily disposed of. He congratulated the society on the excellent work it had done with regard to refractory materials, and also with regard to the establishment of standard clauses and conditions of contract.

The third event, in chronological order, was the reading of a paper before the Royal Society of Arts, last Wednesday, the 18th inst., by Mr. Horace M. Thornton, M.I.Mech.E., on "The Application of Coal Gas to Industry in War Time: Its National Importance." In this the author called attention to the insistent demand that was made in this country for more munitions of all kinds. Labour had been largely reduced by the enlistment of men for the various Fronts, but the gas furnace was, fortunately, being resorted to in increasing proportions; it economised labour, since no stoking was required, no fuel had to be transported, no clinkering had to be done, no ashes had to be removed, and very much less time was lost pending heating-up. In new factories it led to an economy in space and to an increase in output per unit of factory area. No smoke-stack was required. The gas furnace, owing to its easy, accurate control of temperature and its constancy of action, speeded-up the output.

In order to show the increase in the use of gas for industrial purposes, Mr. Thornton gave the following figures for the last year of peace, 1913, and for the year ended December 31, 1916, recorded by the gas works in eight industrial towns:—

—	District.	Annual Consumption for Industrial Purposes.		Percentage Increase.
		1913.	1916.	
		cub. ft.	cub. ft.	
A	Midlands ..	110,707,000	174,167,000	57
B	Midlands ..	327,047,700	420,490,600	28
C	Yorkshire ..	10,760,800	21,583,700	100
D	North-East..	187,473,300	321,841,800	72
E	North-East..	650,000,000	1,650,000,000	154
*F	Midlands ..	1,901,392,000	3,500,000,000	84
*G	Midlands ..	65,882,200	140,000,000	112
*H	North ..	720,032,300	1,155,461,810	84

* These figures are to March, 1913, and (estimated) to March, 1917, in each case.

With regard to individual factories he gave the following figures, which record extraordinary increases of consumption in nine typical cases:—

—	1913.	1916.	Percentage Increase.
A	3,618,300	15,579,000	330
B	3,631,400	19,407,200	434
C	5,202,800	9,845,100	89
D	4,944,900	14,836,900	200
E	1,187,000	40,546,000	3,314
F	818,500	8,314,900	923
G	23,390,400	52,043,500	122
*H	—	111,407,200	—
*I	—	40,000,000	—

* New factories recently opened.

Mr. Thornton concluded his paper by emphasising the urgent need there was of husbanding our coal resources; he also called attention to the gain which could be effected, in the shape of by-product recovery, by an increased use of gas as a substitute for coal.

PRUSSIAN STATE ELECTRICITY.

A FORTNIGHT ago the announcement was made that the Board of Trade had appointed a strong committee to consider how an adequate and economical supply of electric energy could be provided for all industries. This was preceded by a committee to secure the linking-up of existing supply stations to effect economies. The supply of cheap power is one of the necessities of the future, and is occupying attention in other countries also. In our issue of December 22, 1916, we gave an account of what is being done in Saxony, Bavaria and Baden, and now we learn that Prussia is following the same path. Sooner than expected an official announcement has been made by the Prussian Government to the effect that it is proposed to establish a State electricity supply, thus following the examples set by other German States. Whilst a transfer of the various State railways to the German Empire has recently been advocated, as a means of obtaining increased efficiency and uniformity, the plan of an Imperial electricity scheme seems now to have been abandoned, each State being about to make its own independent arrangements.

It is not, however, the intention of the Prussian State to inaugurate a complete State generation of electric energy, nor even a monopoly of the large power supply. The former system would entail the purchase of all existing electricity works, both large and small, which would encumber the State with a number of antiquated and unremunerative concerns. It would further involve the difficult problem of dealing with the industrial private works, which play a considerably larger part in the aggregate supply than do the public electricity works. Thus in 1913 the private concerns were estimated at an aggregate capacity of 8,000,000 kw., against only 2,000,000 kw. of the public electricity works. These former worked cheaply because they had no extensive and costly distribution systems, and so could compete with large distribution plants.

The taking over by the State of the existing central stations would entail an outlay amounting to between 6,000,000,000 marks and 8,000,000,000 marks. As the result of these considerations the Prussian State seems to have decided upon a similar policy to that adopted in Saxony as the means of securing a predominant position and perhaps eventually a monopoly in the generation of electricity—by producing current on such favourable conditions that all private consumers will find it advantageous for the future to draw their supplies from the State. This means that the State will construct a number of huge electric power stations, based upon water power, coal, or lignite or peat gas, from which power stations high-voltage energy is to be transmitted to the private works, which remain independent. The transforming and the distribution of the current to the direct consumer is to be done by the existing local works and stations, which will buy in bulk.

Under the existing circumstances, when the various German States are eagerly looking for new objects for taxation, the Prussian State will hardly embark upon such a large scheme as State generation of electricity unless it can be shown to yield an additional return to the exchequer. According to Professor Klingenberg, who is a strong advocate of the scheme, the construction of the large State power stations in question would entail an outlay of some 900,000,000 marks, which, in ten years' time—say in 1926—should yield a sum of 41,000,000 marks in net profits, in addition to 5 per cent. interest on the outlay. This calculation, however, applies to the whole of the German Empire. In order to obtain this result Professor Klingenberg holds that the actual sale of energy by the public works in the State electricity scheme should be raised from 2,800,000,000 kw.h. to 10,000,000,000 kw.h. He also advocates a tax on lighting electricity and on lighting gas and a tax on coal, which latter has since materialised independently of all State electricity (see page 309 *ante*). Apart from any additional taxation, the electricity scheme, according to Klingenberg, would mean a revenue to the exchequer of Prussia of some 30,000,000 marks in ten years' time.

State electricity, however, also promises other satisfactory results apart from those merely financial. It will no doubt mean increased efficiency of supply, more especially for small places. Further, it will be a powerful agent in the rational exploitation of peat deposits. The Siemens-Schuckert-Wiesmoor central station, which uses peat, has yielded very satisfactory results; it now only remains to be seen whether there are peat deposits of a sufficient magnitude available for the State in this connection.

According to Professor Klingenberg, Germany has only three really large electricity works, viz., the Berlin Electricity Works, the Upper Silesian and the Rhenish-Westphalian power stations. The rest are classified as moderate-sized or small. He emphasises the advantages of power stations, say, from 15,000 kw. to 20,000 kw., for which he puts the cost of construction at 150 marks per kilowatt, whilst the corresponding figure for medium-sized works is put at 200 marks, and for small plants about 300 marks per kilowatt. Also the working cost is notably lower for good-sized stations than for smaller ones. At the former energy can be generated at 40 per cent. less than at medium-sized works and three times as cheaply as at the small stations. Professor Klingenberg's scheme, which now seems to have found favour in high places and, if modified, is likely to be realised, has caused a great sensation and has also met with hostile criticism, especially on the part of the owners or directors of individual supply stations. His figures and conclusions have been questioned or flatly contradicted; an electricity monopoly is being denounced as the death of all industrial progress, and 100,000 volts as risky and unreliable. It will be interesting to watch the further development of the Prussian State electricity plans, and a decided move may, no doubt, be promptly expected.

An important point in dispute is the question of the saving in fuel by the erection of large State power stations. The public electricity works at present use only about 2 per cent. of the country's aggregate production of coal. The consumption of coal at comparatively small stations at present is stated to be from 1.00 kg. to 1.25 kg. per kilowatt-hour, and even with very large units it could not be brought below 0.9 kg. per kilowatt-hour. This is at the switchboard, and there would be an increase of 0.1 kg. per kilowatt-hour at the consumer's terminals. The reduction in railway carriage is negligible, as the estimated quantity of coal only amounts to 0.8 per cent. of the aggregate goods traffic.

The low figures for production quoted in defence of the scheme take no account of the cost of distribution or of interest on capital. The small consumer generally pays three to five times the actual works cost. Many large industries have waste heat or gas available for electric generation and supply themselves at a lower cost than any public scheme can offer.

In agriculture an annual consumption of 2,000 kw.h. per square kilometre is not exceeded, whilst in industrial districts, in Saxony, for instance, the demand rises to 14,000 kw.h., and in Rhineland-Westphalia even to 40,000 kw.h. per square kilometre. Even if the Prussian State would supply energy free of charge no material change could be reckoned with as regards agricultural districts, except for the introduction of electric ploughs.

A centralisation in the production of electric energy is going on in Germany in a gradual and sound manner, and it is urged by opponents of the scheme that the historical development of a decade cannot be superseded all at once. Of the existing electricity works some 500, on an average, supply 50,000,000 kw.h. each in a year, whilst 2,500 electricity works supply annually an average of 100,000 kw.h. each. Practical and natural evolution tends to connect these latter 2,500 works with the 500 works, and the interference of the State would not materially further this development, as the State, it would seem, means to keep aloof from the difficulties this movement might entail.

It will be seen that the Prussian State electricity scheme finds many opponents; however, it has now apparently been finally decided upon, and it only remains to be seen how it will be realised and how it will work.

FERRO-CONCRETE VESSELS.

THE fact that the building of ferro-concrete vessels has been commenced on a fairly large scale, first in Norway and now also in Sweden and Denmark, has naturally centred a considerable amount of technical interest on the question. In Sweden it has been discussed at some length, both in the technical press and at meetings of engineers.

One of the points which has been insisted upon by opponents of the material is the inability of concrete to resist the influence of salt water, however excellent it admittedly is in fresh water. The danger arises from the lime liberated, in the process of hardening, entering into combination with the sulphuric acid and magnesium salts of the salt water. At the instance of the German Concrete Union, the Prussian Department for Public Works, and other authorities, some extensive tests were commenced at the island of Sylt in the North Sea, and these tests have not yet been terminated. Concrete blocks were laid on the shore, fully exposed to the chemical and mechanical influences of the sea. The blocks were moulded in two mixtures, A and C, the cement of the former containing about 65 per cent. of lime, and that of the latter only 61 per cent. to 62 per cent. But the latter was richer in alumina and iron, 10 per cent. to 12 per cent., against 6 per cent. to 8 per cent. in A. The concrete blocks were so placed on the shore that at high water they were entirely submerged, and at low water only partly so. After as little as 2 to 3 years the C blocks, even such as were moulded in mixtures 1 : 2, showed fine cracks, and after 3 to 4 years the surfaces had all suffered much. The A blocks, in a rich mixture, stood the test better, and in mixtures 1 : 2 they were unaffected after 4 to 5 years; with poorer mixtures, 1 : 4, the edges had suffered, and with still poorer mixtures were much affected after as little as 1 to 2 years.

Recent experiments in the United States have shown that an addition of 5 per cent. of finely ground clay to a mixture 1 : 3 : 6 rendered it more resistant, also more so than the same mixture with 10 per cent. of lime added. On the whole, however, all the test blocks suffered more or less.

In spite of all this there are numerous cases in which concrete has withstood the influence of salt, even very salt, water quite satisfactorily; it is in almost universal use for harbour works, &c. The current explanation of the unfavourable effect of salt water upon concrete is that the sulphate of magnesium in the water combines with the lime in the concrete, forming sulphate of calcium, which is of larger volume and therefore has a bursting effect upon the concrete. There are, however, many other kinds of cement, and especially cement of the so-called puzzolane type, not only free from a surplus of lime, but with a surplus of silicic acid, and thus able to bind free lime. The addition of such kinds of cement and other substances containing silicic acid has therefore for a series of years been used as a protection against the undesirable effects of salt water.

In the reports for 1915 from the Gross Lichterfelde West Material Testing Institution some exhaustive laboratory experiments as to the influence

of different solutions upon concrete mixtures of 1 : 3 and 1 : 6 were dealt with. The concrete was, as a rule, exposed to the effect of the solutions during a period of six months, a comparatively short time, but, on the other hand, the solutions were strong, as much as 10 per cent., or entirely saturated. Portland cement, with 63.23 per cent. of lime, was used. The following solutions were employed at the tests:—(1) Chloride of sodium, up to 100 grammes per litre; (2) sulphate of sodium, up to 100 grammes per litre; (3) sulphate of calcium, saturated; (4) sulphate of magnesium, up to 100 grammes per litre; (5) chloride of magnesium, up to 100 grammes per litre; (6) chloride of calcium, up to 100 grammes per litre.

The 1 : 6 concrete was all more or less affected, but all the 1 : 3 concrete tests showed that no harm had been done to the concrete, except in one case, in which the block had been kept in a closed exsiccator during the hardening, and had been submerged in sulphate of calcium solution. The use of too much fine sand in the mixture is undoubtedly injurious. This was shown very plainly in *Le Cement* last year. The unsatisfactory result of the American tests already referred to may to a great extent be attributed to the very fine sand which was used for the mixtures.

It is clearly evident that concrete can only be affected by sea water to the extent the water penetrates it. If the concrete is sufficiently dense, nothing but the surface is exposed to any risk, and the making of dense concrete is no longer a novelty. It goes without saying that more especially in concrete vessels every possible care is taken in this respect.

Protective measures in the construction of concrete vessels may be summed up as follow:—(1) The use of rich concrete; (2) The use of cement with but little free lime, gypsum and alumina; (3) the addition of puzzolane to fix the free lime; (4) the use of coarse sand; (5) the use of dense concrete; (6) surface treatment. Should the cement boat-building industry develop there should not be much trouble in guarding against decay if full use be made of our present knowledge.

In conclusion the advocates of concrete as ship-building material urge that concrete in any case is more resistant than steel. The fact remains that reinforced concrete vessels are in existence and are being built, although it is premature at present to express any definite opinion as to their durability and strength.

NOTES.

THE WILLESDEN-WATFORD ELECTRIFICATION.

THE electrified passenger-train service from the Bakerloo tube to Watford was inaugurated on Monday last with trains provided by the London Electric Railway Company, although from Queen's Park to Watford the track belongs to the London and North-Western Railway Company. The latter have, however, under the special conditions of the time, been unable to procure more stock than suffices for an electric service to Richmond. The new service runs underground from the Bakerloo terminus at the Elephant and Castle to Queen's Park and thence in the open to Watford, a total distance from end to end of 20 miles 66 chains, and the booked time for the trip is about one hour. *En route* a call is made at Willesden. Main line passengers are thus provided with a direct service to four important Metropolitan railway termini, viz., Paddington, Marylebone, Charing Cross and Waterloo. The trains having to pass through the tube are relatively light, the five cars, two motors and three trailers, weighing about 110 tons unladen. The motor cars, which were built by the Brush Electrical Engineering Company, Limited, Loughborough, are 47 ft. 9 in. long over all, with a body width of 8 ft. 9 in., the total height from rail-level being 9 ft. 3½ in. The weight of these cars, fully equipped, is 30½ tons each. Each car is fitted with two motors of 240 h.p., geared for a free-running speed of 35 to 40 miles per hour. The current is furnished at 600 volts, and the control equipment has been supplied by the British Thomson-Houston Company, Limited, of Rugby. The trains which the London and North-Western Company intend to run will not enter the tube, and will accordingly be built to ordinary main-line standards and will require much more power to operate. Each of the motor cars for these trains will accordingly be provided with four motors rated at 240 brake horse-power each, making a total of 1,920 brake horse-power for the whole train. The current for the tube section of the track is supplied from Lots-road, but that for the section between Queen's Park and Watford is taken from the Willesden power station of the London and North-Western Railway Company. Here there are three 5,000-kw. units installed, a number which is ultimately to be increased to five. The turbines are of British Westinghouse make and are coupled to Siemens generators. The steam is supplied at 200 lb. gauge pressure and at 200 deg. F. superheat. Cooling towers have to be relied on for the condensing water supply, but no difficulty has been found in maintaining a vacuum of 28 in. This station and the electrification of the Watford line generally has been carried out to the plans of Lieutenant-Colonel F. A. Cortez Leigh, chief electrical engineer to the London and North-Western Railway Company, who, during his absence on active service, has been represented by his chief assistant, Mr. George Broughall.

FOREIGN LANGUAGES FOR ENGINEERS.

The Institution of Civil Engineers has decided to add a knowledge of some foreign language to its syllabus of subjects for examination. This change will come into effect early in January, 1919, after which time every candidate for election to associate membership will be required to show a suitable knowledge of one of the following languages—German, French, Hindustani, Italian, Russian or Spanish—unless he has previously qualified at a preliminary examination recognised by the Institution. For the present the requirements are not onerous, varying from translation from a newspaper, magazine, or commercial letter in some foreign language to the writing of a composition on a given subject. There can be no doubt as to the wisdom of the new regulation. British engineers have always found a good deal of their employment abroad, or in supplying goods to other countries, and have often encountered difficulties in dealing with their clients or customers from their inability to put their ideas in words intelligible to those with whom they dealt. The late Mr. Leslie Robertson used to relate that when he joined the board of the Schmidt's Superheating Company the directors were of about equal numbers of Englishmen and Germans, none of whom could speak any language but his own. Communication took place through an official, and the result was such as might have been anticipated. Whether due entirely to Mr. Robertson's linguistic abilities, or to other causes in addition, we do not know, but the company rapidly attained success after he joined it. There is no doubt that in the future a knowledge of foreign languages will become increasingly valuable in business, and that if we are to take advantage of the splendid opportunities which will open up on the attainment of peace our young men must begin at once to direct attention to them. There are cases, of course, in which no commercial gain will be secured, but there will always be an intellectual advantage. Technical instruction is very apt to be narrowing to some minds, which are of a type that cannot perceive the wood for the trees, and a literary study forms an admirable corrective to this tendency. There are, however, few engineers who would not be the better, from a business point of view, for being able to read some European language. Knowledge is being attained so rapidly that it is quite impossible to record all advances in English papers and books, and hence particulars of new developments must often be sought in foreign publications. Even if similar information is available here there is always an advantage in seeing it portrayed as it appears to a different type of mind from that which obtains at home. A man must be very dense if recent events have not brought it home to him that our methods of ensuring progress stand in great need of improvement, and that we can learn much both from friends and enemies. Primarily our methods of teaching languages must be revised. Nearly every boy at a public school learns French, and yet there is scarcely anything to show for it. The little he retains is some knowledge of grammatical rules, but these are useless to a man who has no vocabulary. They are like skill in book-keeping to one who has neither money nor business to render account of. With a fair stock of words it is possible to go far in a foreign country, but grammar without words is like a boiler without water or fuel.

DIELECTRICS IN ELECTROSTATIC FIELDS.

The problem whether dielectrics will change their dimensions when exposed to strong electrostatic fields has received little experimental investigation. One would expect some change, although not more than a small change probably. Righi and Quincke made some experiments thirty years ago, and Cantone and Pozzani followed the matter up in 1900; but the results were not concordant. Resuming these investigations recently, L. Bouchet (*Comptes Rendus de l'Académie des Sciences*, August 17 and October 30, 1916) first studied the expansion in a direction normal to the electric field. He placed cylinders of glass, paraffin or ebonite between two concentric cylinders of brass, filling the annular space left with water; the system formed a tubular condenser. On the top of the cylinder of the dielectric material he placed a glass plate, and on this a lens; when the electric field was excited by an influence machine (Voss) the cylinder expanded in the direction normal to the electric field and pressed the glass plate against the lens, causing displacement of the interference rings. The length of the cylinders was about 40 cm., the diameter 1.5 cm., the thickness up to 2 mm. The expected dilatations were observed, but they amounted to 1 part in 10^{10} or less. The expansion was proportional to 1/E, however, E being the Young modulus of elasticity, an interesting relation. On the other hand, the numerical results were not what they should have been for perfect dielectrics, and glass and ebonite (half-hard), which disagreed most, are, indeed, far from being considered perfect dielectrics. There seemed to be no direct external electrostatic pressure effect on the length of the insulator. In the second series of experiments Bouchet studied the effect of the electric field in the direction of the electric lines of force. The electrostatic pressure effect would probably be more marked in this case, and there might be superposed either a contraction or a dilatation of the dielectric owing to the internal stress. The materials chosen for these experiments were pure Para rubber, vulcanised or unvulcanised, and, further, glass. Discs were formed, 15 cm. in diameter, up to 0.65 cm. in thickness, and stuck (with paraffin) to discs of brass; on the top of each disc was placed a piece of aluminium or tinfoil, the brass and foil thus forming the condenser electrodes. Changes in the thickness of the disc were again measured by the method of interference. In the case of the vulcanised rubber the observed contraction (amounting to 22×10^{-6} cm. maximum) was somewhat larger (although less than 100 per cent. larger, certainly) than the calculated contraction, and increased with the square of the field intensity; the unvulcanised rubber seemed to conduct the current and behaved less satisfactorily. In order to ascertain whether the direct electrostatic pressure (attraction between the top and bottom of the condenser) was an important factor, Bouchet piled five of the vulcanised rubber condensers upon the top of one another, to form a multiple condenser; in that case the direct attraction effect should be the same as in a simple condenser, because the attractions upwards and downward would balance one another in the intermediate condensers (of the multiple arrangement). The observed contractions were double those of the experiments with the simple condenser. Thus the contraction due to the internal electric stress would appear to be much stronger than the direct pressure effect.

SULPHUR IN PETROLEUM OILS.

To the metallurgist sulphur is largely a nuisance, to the petroleum technologist it is altogether a nuisance. The sulphur is held responsible for the vile smell of some petroleum—though certain unsaturated hydrocarbons ought to share the responsibility—for the mischief done by lamp oils to the decorations and books of our rooms, and for the pitting by fuel oils of boiler plates and tubes. The

sulphur contents may badly depreciate an oil, and all these evils become accentuated in the Kimmeridge shale oils, the large deposits of which are now being utilised in this country, so far as the 5 per cent. or 7 per cent. of sulphur they contain will permit. Dealing with these important and difficult problems in the Institution of Petroleum Technologists on March 20, Dr. F. Mollwo Perkin, F.I.C., suggested that the percentage of sulphur in natural oils seemed to vary with the origin of the petroleum; oils of vegetable origin were apparently less rich than animal oils, and if the sulphur percentage went up to 2 and 3, inorganic sources, reduced calcium sulphate, *e.g.*, might be thought of—a suggestion which Mr. Cunningham Craig would not accept. The sulphur in the oil might be dissolved as such, or be present as sulphuretted hydrogen, free or evolved during the distillation, or present in organic compounds of great variety, thiophene, C_4H_4S, thiophane, C_4H_8S, methyl sulphide, $(CH_3)_2S$, and homologue alkyl sulphides, disulphides, mercaptan, C_2H_5HS, &c. When the oil was distilled the sulphur was found chiefly in the constituents of higher boiling-points and in the residue. But the isolation of the compounds was very difficult because they had nearly the same boiling-points as some hydrocarbons, especially unsaturated, likewise present in the oils. Strong sulphuric acid dissolved and removed both the sulphur compounds and the unsaturated hydrocarbons, and the acid treatment for the removal of the sulphur might become too costly for this reason. There were some other characteristic reactions of the sulphur compounds, but there was much left to be done by the research chemist. The first attempts to desulphurise oil on a large scale had been made in Canada in 1869, superheated steam being used. The cupric oxide processes—largely used by the Standard Oil Company, as Sir Boverton Redwood mentioned—relied on reactions of the oxide, either with the vaporised oil or with the oil itself; in the Frash process, first applied to the Canadian "skunk" oil, and its modifications, oxides of copper, lead and iron were the chief reagents. Sodium plumbite had been used; calcium carbide had been used by H. B. Blackmore; in the important process of Edeleanu liquid sulphur dioxide was the separating agent. Dr. Perkin himself, in conjunction with Messrs. Lucas and Palmer, is trying the action of ammonia gas on petroleum heated under such a pressure that the oil cannot gasify, while the ammonia is dissociated; they also treat oil vapour with ammonia, but Dr. Perkin could not yet give particulars as to results. The treatment of the Kimmeridge shale oils was very difficult because they contained and retained water, and because most of the reagents used to remove the sulphur also attacked the oil. That these shale oils must be kept apart from petroleum was emphasised during the interesting discussion. But Sir Boverton Redwood was in a position to speak of a promising outlook of the important Kimmeridge oil problem, and Mr. Anfilogoff considered the difficulties not unsurmountable on the whole by the aid of suitable group reagents; he recommended hydrogenation of the unsaturated compounds, also of the shale oils. In this Dr. Blackler concurred; Dr. Thole advised the use of caustic soda and sodium plumbite; Dr. Lomax stated that cracking itself desulphurised. Though the speakers differed as to the efficiency of some reagents, the engineer may yet hope to be relieved of the sulphur nuisance in oil.

THE INSTITUTE OF METALS.—On Thursday, May 3, in the Hall of the Institution of Civil Engineers, Great George-street, Westminster, the seventh May lecture will be delivered by Professor W. E. Dalby, F.R.S., on "Researches made Possible by the Autographic Load-Extension Optical Indicator." Visitors are welcomed, and tickets can be obtained on application to the secretary at 36, Victoria-street, Westminster, S.W. 2.

THE ASSOCIATION OF ENGINEERING AND SHIPBUILDING DRAUGHTSMEN—BIRMINGHAM AND DISTRICT BRANCH.—Interesting statistics respecting the work and progress of the association were given by the chairman at a meeting of this branch of the association, held on the 14th inst.; it was gratifying to draughtsmen to learn that their numbers now in Birmingham as members of the association were about 295, representing 50 firms. This brings the total up to something like 8,000 members in Great Britain and Ireland.

LITERATURE.

The Portland Cement Industry; A Practical Treatise on the Building, Equipping and Economical Running of a Portland Cement Plant, with Notes on Physical Testing. By WILLIAM ALDEN BROWN, Assoc.Am.Soc.C.E. London: Crosby Lockwood and Son. [Price 7*s.* 6*d.* net.]

IN view of the coming struggle in the commercial world, in which eager and competent rivals will strive for supremacy, urgent calls have been addressed to our manufacturers to brace themselves for the coming conflict by employing more economical methods of production and by paying greater attention to technique and the deductions of science. Unfortunately for the producer, the acceptance of these insistent demands usually involves some sacrifice, as the scrapping of machinery or the abandonment of familiar and cherished processes. Mr. Brown joins in this demand for renewed exertion, and finds his opportunity for urging greater enterprise and alertness by discussing the present position and prospects of the Portland cement trade. His view is gloomy, but his dismal Cassandra warnings are tempered with wholesome advice and skilled counsel. We hope that he will not prove as a voice crying in the wilderness, for his anxiety is well founded, and very considerable efforts will have to be made if the industry is to be placed on a satisfactory footing against the severe competition with which it is threatened. It is perfectly true that the cement trade had its origin in this country, but that is not an unmixed advantage. The benefit of early experience is outweighed by having to defray the cost of experiments, of which later comers in the field reap the results without a similar expenditure. The lot of the pioneer is an honourable but not necessarily a lucrative one. We are handicapped by obsolete methods, by capital sunk unprofitably, by natural dislike to change, and in other ways, so that it is little wonder that our manufacturers have been unable to hold their own against younger rivals, assisted by better organisation, improved science, and probably by easier access to markets. Germany and the United States have both passed us in the supply of this important constructive material, destined to render possible those gigantic engineering feats in the future, of which in our day the Panama Canal and the Barrage of Assiout are worthy examples. In 1913 our output was 3,000,000 tons; in Germany, 5,000,000; while in the United States the total production exceeded 15,000,000 tons.

The author's explanation of the diminishing output in comparison with the progress effected in other countries seems hardly adequate. He ascribes it to the incapacity, or unwillingness, of British firms to equip cement works with modern plant complete in all details, and though he frankly admits that this unsatisfactory attitude no longer exists, he cannot view the future with confidence, because of the greater inventiveness of the American mind and the readiness with which new ideas and projects are welcomed and assimilated in a more progressive country. However injuriously such causes may have operated in the past, there is no doubt but that the want of standard tests, ensuring constancy and reliability in quality, and in extreme cases leading to the insistence by individual engineers on arbitrary and varying specifications in their contracts, had an adverse effect. The British Standard Specification, detailing the character and the treatment of the resulting clinker, and prohibiting the addition of any material, after burning, other than a small proportion of calcium sulphate to regulate the setting, has acted beneficially. A drawback of quite equal extent was the slight encouragement given to chemical research as an aid in overcoming the difficulties that manufacturers encountered in the various stages of the general process. The advantages to be won by fine grinding of the raw material, or of the reason for its necessity, were recognised but slowly. The early makers, too, did not prepare the clinker by calcining the mixture to the point of incipient fusion, being probably unaware of the importance of promoting the chemical combination of the lime with the silica and alumina of the clay, in order to produce a compact and stable clinker. Further, the cement industry has undoubtedly profited by progress in the construction of machinery used in the fine grinding of rocks in mining and metallurgical processes, for though the author has set out very fully the methods employed in this particular industry, not all of them have a unique application: they have relations and analogies elsewhere in the industrial world which it is well to recognise.

A line of division, peculiar to cement manufacture, results from the adoption of either the wet or the dry process in grinding and preparing the raw material. The determining factors in selection are the composition of the rocks operated upon and the cost of production, for with equal care in the mixing, grinding and calcining, equally successful cements are produced by either method. The author, assuming that modern appliances are available, favours the wet process, and intimates that by this method the dry is being gradually excluded. If this opinion is well founded it implies a preference for the use of clays and soft materials containing about 30 per cent. of moisture. By the addition of water such a mass can be easily ground to the necessary fineness of impalpability, giving rise to a slurry of so great a watery content that it can be freely pumped into tanks, in which it can be kept under supervision till it is in a fit state for burning. On the other hand, where crystalline limestone is the raw material available, the dry process of crushing is inevitable, and those who employ it, either from necessity or choice, urge that where the necessary evaporation is so much less, the saving in fuel consumption compensates for any disadvantages. The author counters this argument, and we think justly, by pointing out that even where a perfect mixture of lime, silica and alumina may be admitted to exist at the outset, yet in the passage through the rotary kiln the due proportion of lime will not be maintained, owing to the scattering influence of the strong draught of the kiln on the lime after the carbonic dioxide has been driven off. The author contrasts the arguments for and against very fairly, but that both processes are carried on is a tolerably convincing proof that the advantages and disadvantages are pretty equally balanced, and that the price of fuel and of materials, coupled with general convenience, is the deciding factor in determining the procedure.

The choice of site, securing easy access to canal or railway transport; the methods of excavation; the plans for local exhaustion of material with avoidance of waste; removal and treatment of overburden, do not differ from quarry practice generally. One feature on which the author insists is the adoption of big-hole blasting drills. It is contended that the cost per ton of drilling is less, and a considerable saving effected in explosives. The risk to the workmen is diminished and the rock is broken finer, requiring less handling and reducing in the preliminary crushing. The author gives comparative data showing that the saving per ton by big-hole drilling is about 6 cents. This may not seem a large amount absolutely, but where great quantities are handled, it must be remembered that the profit per ton is also small. We are, however, more impressed by the statement that the blast hole of about 5¼ in. diameter has been adopted by all "the leading and up-to-date cement, lime and stone companies throughout the United States."

Crushing and grinding of the raw material are effected by machinery that has its counterpart in other industries. The essential point is to ensure the finest possible state of subdivision in the most effective manner, and the author describes and illustrates several machines that are on the market. A moderately sized plant will have the task of crushing weekly a bulk mass of about 8,000 tons to such an impalpable powder that 90 to 95 per cent. will pass through a sieve of 180 meshes per linear inch. The evolution of the necessary machinery has been long and costly, and the degree of perfection now attained cannot be readily appreciated.

The rotary kiln is to a great extent the product of this particular industry; certainly its development has been due to trade necessities, while its continual improvement has operated most beneficially on the quality and amount of the output. The conception of a rotary furnace is of English origin, suggested by Crampton in 1877, and patented by Ransome in 1885, but, like many other nascent ideas, the

practical development has been pursued in foreign countries. America burns practically all her Portland cement in an improved and glorified Ransome, Germany some 70 per cent., but Britain has so far neglected her own invention that only 60 per cent. is treated by this method. Ransome's kiln was of a modest and experimental kind, being only 26 ft. long and 5 ft. in diameter, fired with "producer gas," a very good idea, but he experienced great difficulty with the lining of the cylinder, difficulties that have not yet been entirely surmounted in the most modern examples. Kilns of 200 to 230 ft. in length by 9 ft. in diameter are now running, and producing 170 to 190 tons of cement clinker every 24 hours. The fuel consumption—usually coal dust—is noticeably less than in the stationary type of kiln, but the great advantage consists in utilising the heat of the clinker itself on leaving the kiln, the heat being returned to the firing zone.

The work of the power plant in a cement factory is much the same as elsewhere, calling for the same attention and liable to the same interruptions, whether it be electrical, or supplied by gas engines, by reciprocating steam engines, or steam turbines. There is no peculiarity that calls for remark, further than that in the case of rotary kilns of large dimensions reliable and constant power is imperative. Continuous running is essential to economic conduct of works.

The chapter on costs and statistics is interesting and worked out in great detail, with specimens of forms for systematic cost-keeping. The following table, compiled after close analysis of the total cost of producing one ton of cement in a typical factory of 3,000 tons per week capacity, is instructive, but the amounts stated will probably be considered by experts as underestimated :—

	Pence.
Labour	31·15
Laboratory	1·20
Superintendence and Office...	4·65
Supplies	99·50
Total per ton ...	136·50 = 11s. 4½d.

In the item "supplies" coal is reckoned at 14*s.* per ton. The cost of plant may be put down at 30*s.* per ton of annual output.

The last chapters, and not the least important, deal with the testing of cement, the criteria that are recognised in British Standard Specifications, and the difficulties that beset the inexpert, both in making the tests and in interpreting the results. Few would probably care to trust to their unaided skill in determining the chemical composition, the specific gravity, the degree of fineness of the finished cement or the tensile strength when mixed with sand. Nevertheless definite and precise directions are given which may be followed without difficulty, but practice and training are necessary for accurate quantitative results.

BOILER EXPLOSION AT DERBY.

A FATAL explosion, due to the failure of a tube in a patent water-tube boiler, occurred at the Electricity Works of the Derby Corporation on Wednesday, February 21, and though comparatively little damage was done to property, one man was killed and another severely injured by scalding. At the coroner's inquest, held at the Guildhall, Derby, Mr. G. T. Lee, solicitor, represented the Corporation, and Mr. A. R. Flint, solicitor, appeared on behalf of the mother of the deceased man, Harrison. Mr. Eatock, Nottingham, inspector of factories, was also present.

The first witness called was Frederick Harrison, who deposed that the deceased, who was his brother, was 37 years of age, and was deaf and partially dumb, and had been employed as labourer at the works for about twelve months during the depletion of the staff.

Thomas Poxon said he was employed as fireman at the Electricity Works. There were five boilers in the boiler-house, all coupled together, and the one in which the accident occurred was No. 16. On Wednesday, February 21, he was passing through the boiler-house, when he heard what he termed "a horrible report," and immediately disconnected the boiler; a volume of steam and hot water issued from one of the tubes, the basement below being filled with hot water in a few seconds. In this basement two men were working at the time, and they were terribly scalded, one of them being rescued alive, but the other was found lying dead in a foot of water. Witness had made an examination of the boiler six weeks previously, when he cleaned it out, and he added that 200 tubes of a similar kind to the one that had burst were in the boiler. A portion of the ruptured tube was produced for the inspection of the coroner and his jury.

In reply to Mr. Eatock (factory inspector) witness said that the exits in the boiler-house were respectively about 9 and 6 yards from the boilers.

Frederick Cooper, boiler-house foreman, described the efforts made for the rescue of the injured men, and was asked by the coroner whether he considered the boiler-house dangerous. Witness replied that he could not say whether it was or not.

In reply to the Town Clerk, witness said that he had been employed at the power station for about fourteen years, and had never known of a fatal accident previously. There had been a minor accident in connection with one of the old-fashioned boilers previously in use, but this was the first accident that had happened in connection with the newer-type boilers.

Mr. Thomas Percival Wilmshurst, chief electrical engineer to the Corporation, said he was absent from the power station at the time of the explosion. The boiler in question was made by Messrs. Babcock and Wilcox, of Glasgow, and was only laid down in September, 1914. The tunnel in which deceased was working at the time was 9 ft. high and 12 ft. wide, and there were two permanent exits with ladders fixed. Probably 90 per cent. of the electric power stations in England used the same type of boiler as those used by the Derby electricity works, which were as up-to-date as any in the kingdom, and during the 24 years that the works had been open there had never been a fatal accident. The boilers were insured, and regularly inspected by the Vulcan Boiler Insurance Company, and a thorough examination was made every year, together with two or three supplementary external examinations. In addition, the engineers employed at the works also examined the boilers every month at the cleaning times. No defects whatsoever had ever been found in the tubes either by the insurance company's inspectors or by the men themselves. The last thorough inspection of the boiler was made on October 12, 1916, by Mr. Walker, one of the insurance company's inspectors, and at that time every tube was thoroughly examined and no defect discovered. Witness read to the coroner and his jury the inspector's report, which stated that the boiler was in perfect working order except for a slight leak in a small plug. The tube which had burst and caused the damage was 7½ ft. long; he had examined it carefully and found it exceedingly clean, with practically no scale. At the most the scale was not more than $\frac{1}{32}$ to $\frac{1}{8}$ in. thick. Where the fracture had taken place, naturally the scale was thickest, but the amount was so small that it could not have caused the failure of the tube.

Asked by the coroner whether the metal at the fracture was thinner at any part more than at another, witness replied that it was only to be expected that the metal would be thinner at some parts, as the tube had bulged, thus stretching the metal. The tube was made of solid-drawn steel; the working pressure was 280 lb. per square inch, and the hydraulic test pressure, applied by the insurance company's inspectors, was 380 lb. per square inch. Witness could not account in any way for the fracture, but in his opinion the probable cause of the accident was overheating of the tube, as the fracture had occurred at a part where the furnace was hottest, and where the flames impinged on the metal.

Mr. Eatock inquired from witness what they proposed to do to obviate a similar danger in future. In reply, witness suggested certain alterations by making the two casements, which were used for moving machinery, into permanent exits, with ladders fixed to them, and these alterations he proposed to carry out. Mr. Eatock agreed that this would be wise, but said he thought that in addition a part of the machinery called the conveyor should be covered with a shield, in order that a man, if in danger, might be able to fling himself over it. Mr. Wilmshurst promised to carry out these recommendations, and added that the maker of the tubes used in the boilers subjected them to a test pressure of 1,500 lb. per square inch, which made him more sure than ever that the failure of the tube was not due to any defect.

Mr. William Bayliss, Manchester, engineer in the employ of the makers of the boilers, said that he had made an inspection of the tube which failed, and agreed with the previous witness that the disaster had been occasioned by over-heating.

Mr. Flint, on behalf of the mother of the deceased man: Do you mean that there was no latent defect in the tube?—Yes.

Was it owing to something curious in the furnace at that particular part that that portion of the tube was overheated and not any other part or any other tube?—There is nothing curious in the phenomenon of local overheating. Raising steam from any but distilled water is a very complex matter.

Mr. James Arthur Aiton, engineer, of Derby, said he had been requested by the coroner to examine the exploded tube, and had made very careful measurements of the various parts and found that the thickness of the metal varied between 0.175 of an inch and 0.125 of an inch. The thickness at the part where the fracture had taken place was only 0.125 of an inch, which amounted to a latent defect in the tube. He did not, however, say that the defect could have been found out by any tests which had been made of the tube, and there had been no neglect whatsoever on the part of anyone concerned in the matter. Witness was of the opinion that the burst had been caused by pressure and not by overheating, as there was a quantity of scale on the outside of the tube that would have been burnt off if there had been any overheating; there might, of course, have been a very slight amount of overheating that would have increased the pressure. It was very unlikely that the fault in the tube would have been discovered by any examination or test.

After deliberation the jury returned a verdict of "Accidental death," exonerating the Corporation from any blame or negligence and expressing the opinion that it would be safer to have the means of exit from the boiler-house improved as suggested in the evidence. The foreman observed that the jury thought the occurrence was one that might happen, no matter what precautions were taken.

THE OPTOPHONE.

IN our last issue (page 359) we published a letter from Dr. E. E. Fournier D'Albe, in which he took exception to the doubt we expressed whether whole words in ordinary type could be read blindfold with the Optophone, and stated that by aid of his Optophone it was possible to read a newspaper by ear with a speed of at least three words per minute, and also typewritten documents, and even carefully written manuscript. Since the letter appeared Mr. Arthur Pearson has made the following communication to the Press :—

Blind Reading by Ear.

SIR,—Some weeks ago a great deal appeared in the Press with regard to an instrument called the optophone, which its inventor, Dr. E. E. Fournier d'Albe, claimed would enable blind people to read ordinary print by sound.

You would not, I am sure, be able to spare me sufficient space to go thoroughly into the scientific problems involved, but I hope you will allow me to inform your readers, and ask them to inform their blind friends, that Dr. d'Albe accepted the challenge of the National Institute for the Blind to prove his assertion that ordinary print could be read at the rate of 25 words a minute—a rate slow enough, I think—by means of his invention.

Recently Dr. d'Albe attempted to justify his claim. He informed me in writing that he had practised for 130 hours upon the particular instrument on which the test was made.

For all practical purposes this test was a complete failure. Dr. d'Albe only succeeded in reading at an average speed of one word in one minute and a quarter.

The opinion of the experts, two sighted and two blind, before whom the tests were made is that the optophone cannot be taken seriously as an aid to reading by the blind.

It is, in short, at present nothing but an ingenious scientific toy, and a very expensive one at that.

It is sincerely to be hoped that Dr. d'Albe may be able to improve the optophone to a pitch which will render it of some practical value. In the meantime I hope he will cease to encourage the belief that the optophone is of any service to the blind reader.

ARTHUR PEARSON, President.
The National Institute for the Blind,
224-6-8, Great Portland-street, London, W. 1.

THE METRIC SYSTEM.

TO THE EDITOR OF ENGINEERING.

SIR,—In regard to the controversy over the metric system, it would be interesting to know how many of the gentlemen who have written so much against the introduction of the system have had any experience in "having to work for their daily bread" either under the metric or our own elaborate system of weights and measures; no doubt very few have done so. It is all very well to talk about our "beautiful system" when one has the time to treat it as a hobby. There is a widespread idea in this country that the metric system is another German plot. Are our arch enemy and her allies the only nations who use the metric system? I think not. As a British engineer who worked for a number of years in Germany, the writer has had the experience, when he came back to our own system, of finding that, as a rough estimate, the latter entailed anything from 30 per cent. to 40 per cent. extra labour in engineering calculations.

Why this talk about us having to alter our Whitworth standards? On the Continent these standards are in use. When all other dimensions are in millimetres, the fact of the Whitworth standard being a fraction is an advantage in that all screwed parts stand out in a complicated drawing.

To come back to weights: compare a Continental pocket-book with our own; in the former all our beautiful tables containing equivalent weights of cubic inches and cubic feet of various materials are omitted, the only table necessary being specific gravities of various materials.

Several have already remarked in this correspondence that less time need be given to children in the teaching of arithmetic when the metric system is used. This is quite correct, as the writer's experience has been that from the age of 11, on the Continent, instruction in arithmetic finishes, and a purely mathematical course follows.

To conclude, the writer would suggest that a better title to appeal to the general public of this country would be to call it "decimal" system, and not "metric" system, the latter appearing to the British public in the form of a bogey, such as technical education, &c.

Yours faithfully,
JAMES B. JEFFREY.

33, Park View, Great Crosby, Liverpool,
April 14, 1917.

TO THE EDITOR OF ENGINEERING.

SIR,—For the first 13 years of my life I was brought up on centimetres, grammes and slide-rules, and I readily admit the simplicity of the metric system. During the next 13 years I was in England trying to learn its language, weights and measures, but I shall never know them thoroughly.

I have lived in Russia and Germany, both before and since Prussia adopted the metric system of weights and measures and the mark—not the franc—and I cannot for the life of me understand all this fuss about compelling

Englishmen to use a portion only of one particular system! Why not insist on all nations using the same language, and having the same coinage, weights and measures?

Personally I have never found any difficulty in *making* things in English and in *selling* them in French, German or Russian, and I know from practical experience that it is not necessary for foreigners to make any changes in their monetary or other systems in order to supply us with their goods at so many shillings or pounds per yard, dozen, gallon or ton.

By all means let school-children be taught the metric system in addition (and a very slight addition it is) to the English want of system; and, if there be any truth in natural selection, the fittest will survive; but I see no prospect of abolishing shillings, marks, roubles, rupees, piastres, pesetas and numerous other coins in favour of the franc.

Your obedient servant,

London, April 15, 1917. "COSMOPOLITAN."

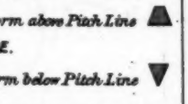
THE MODIFICATION OF THE WHITWORTH SCREW THREAD.

TO THE EDITOR OF ENGINEERING.

SIR,—The recent proposals of Professor Unwin for the modification of the Whitworth screw thread must be very interesting to those who during the last two years have been engaged in the manufacture of screwed parts for munitions. The information which has been collected during this period will no doubt enable recommendations to be made so that in future many of the present difficulties of manufacturing screwed parts may be removed. The fact remains, however, that these parts are being made in many factories and to very fine tolerances, to the credit of our present-day engineers and tool makers. Previous to the war our best screw gauges were imported from abroad, but to-day thousands of gauges are being made which are better gauges than those previously made by any firm abroad.

In considering the manufacture of screwed parts the advantages afforded by having a clearance or allowance at the full and core diameters are very evident. A study of the various other screw thread systems show that in most cases a clearance is provided.

The Cadillac Motor Company, of Detroit, have adopted a form of thread which gives a clearance at the full and core diameters. This is obtained by making the form of the thread on the tap and the die as follows:—



This forms a combination of the V form of thread and the United States standard form. This forms a bolt and nut with a clearance on the full and core diameters shown in Fig. 1 annexed.

The Engineering Standards Committee, in the preface to the first edition of their report on screw threads, remark that they recognise the possible advantage afforded by the Sellers thread in permitting clearance at crest and root. They appear also to have made a series of experimental investigations, from which it was decided to make the tolerances on the full diameter of the bolts slightly in excess of those recommended by the committee for shafts in third and second quality plain cylindrical work.

The same tolerances are specified for the full and core diameter of the nuts, whilst the allowances (which are made on the nuts) are approximately one-third of the above tolerances. These tolerances were prescribed to cover the wear of tools and unavoidable errors in workmanship, and to enable the parts to assemble without difficulty. Tolerances were also prescribed on the effective diameter to cover possible errors in pitch, and the table given below gives the value of the tolerances on full, core and effective diameters for a few sizes of standard bolts and nuts.

Tolerances on Full, Effective and Core Diameters.

Size of Screw and No. of Threads per Inch.	Bolts.			Nuts.		
	Full.	Effect.	Core.	Full.	Effect.	Core.
0.25—20 ..	0.0018	0.0018	0.0023	0.0018	0.0018	0.0018
0.50—12 ..	0.0025	0.0030	0.0032	0.0025	0.0030	0.0025
0.75—10 ..	0.0030	0.0040	0.0039	0.0030	0.0040	0.0030
1.00— 8 ..	0.0035	0.0050	0.0045	0.0035	0.0050	0.0035

A comparison of these figures show that the tolerances on the full and core diameters vary but little from those prescribed for the effective diameter. It is also to be remembered that the effective diameter and the pitch are those which most seriously interfere with interchangeability, besides being interdependent on each other.

The fitting of the screwed parts on the full and core diameters is quite unnecessary, even if obtainable, and for this reason alone the tolerances on the full and core diameters should be increased over those laid down for the effective diameter. In addition to this increase the clearance advocated by Professor Unwin might be adopted, and the formula $c = 0.05\,p$ is certainly a simple one to use. Granted that this could be adopted, then the following method of gauging the work could be employed:—

Gauging Screwed Holes.—At present the method of gauging screwed holes is to use—

1. A screwed plug gauge made to the minimum dimension which must enter.

2. A plain cylindrical core-diameter gauge, which must not enter, of a diameter equal to the core diameter of the screw gauge plus 0.007–0.012. For important holes these gauges could be supplemented by a not-go effective diameter gauge equal to the high diameter.

The form of this gauge could be of the form shown by Professor Unwin, or consist of a few turns only. The full diameter would be reduced and the core diameter deepened.

This form, I think, might be preferable, since gauges of accurate pitch can be made, and a few turns would gauge both pitch and effective diameter. The form would also have the advantage of being not so expensive to manufacture. A sketch of these various gauges is given below, see Fig. 2.

Gauging Screws.—The method of gauging screws is exactly similar to the above method, but ring gauges are used instead of plugs, as follows:—

1. A screwed ring gauge made to the maximum size of the screw, which must pass over the work.

2. A plain ring gauge from 0.007 in. to 0.012 in. below the minimum full diameter, which must not pass over the work. These gauges, too, may be supplemented by a not-go effective-diameter ring-screw gauge. This would consist of a screwed ring with the correct effective diameter, but with the core diameter enlarged and the full diameter crest taken to a point. These gauges would be unaltered if the clearances were allowed, and work which passed these gauging tests could be relied upon.

The clearances, in a very modified form, have already been adopted by several manufacturers. A study of the problem was sufficient to convince anyone who had

Fig. 1.

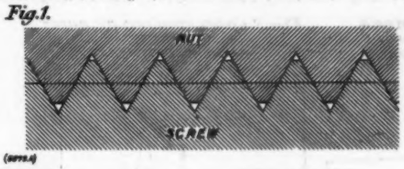
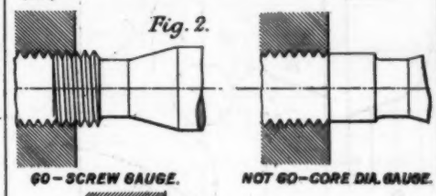
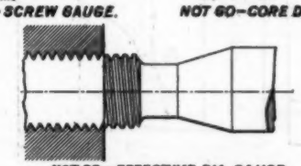
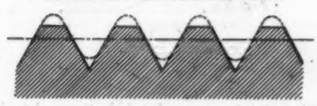


Fig. 2.







charge of plant manufacturing screws that endless trouble would result in trying to obtain full, effective and core diameters on both bolts and nuts to within the limits given on most drawings. Further, it was not difficult to recognise that a bearing on the slopes was all that was necessary, and to confine attention to effective diameters would result in the best work being produced.

A still further consideration was that if we were confident that the full and core diameters of the nuts were sufficiently larger than those of the screw, then two of the elements necessary to interchangeability would not require any attention. For this reason the tools for manufacturing screws and bolts were made in the following manner:—

Producing Tapped Holes.—The drill for the tapping size is made as large as possible, from 0.002 in. to 0.005 in. below the diameter of the not-go plug gauge. This will give a good clearance on the core diameter of the nut, besides making the holes very much easier to thread.

Too often the holes are drilled too small, and this very often is the cause of many tapping troubles.

In tapping soft materials, if the hole is too small the threads may be torn off to some extent. If the hole, however, is drilled rather large the metal is very often drawn a little, so that the diameter of the hole is slightly less after tapping.

The tap for tapping the hole should be made with the core and effective diameters from 0.001 to 0.003 larger than the screw gauge size, but the full diameter, however, should be left from 0.003 to 0.005 larger, so that a good clearance is made for the full diameter of the bolt. Thus the screw gauge, in gauging the holes, bears only on the slope of the threads, since the full and core diameters are made larger by 0.003 to 0.005 in.

Producing Screws.—In producing the screwed part the same procedure is followed. The work is turned to as small a diameter as possible, from 0.002 to 0.005 larger than the diameter of the plain ring gauge.

The dies or chasers are made so that they cut the core diameter from 0.002 in. to 0.005 in. deeper than the effective diameter, so that the screw gauge again bears on the slopes of the threads only.

A further advantage of manufacturing the dies in this manner is that the effective diameter may be increased if required and the core diameter will still remain small enough to clear the gauge. Thus in each operation the tendency is to secure a clearance at the full and core diameters, and this method of manufacturing the tools has made the manufacture of screwed parts very much easier. By going still further and adopting the clearances advocated by Professor Unwin, the Whitworth thread will be quite as good and as easy to manufacture as any of the other thread systems.

I am, yours truly,

Manchester, April 4th, 1917. A. S. M. T.

LABOUR EXCHANGES.

TO THE EDITOR OF ENGINEERING.

SIR,—We are expected to make use of the Labour Exchanges, but if my son's experience is anything to go by, I am afraid many people will fight shy of them. Presumably their functions are to help the exchange of labour, but this seems to be more "honoured in the breach than the observance." Last summer the head master of my son's school was asked to sanction his boys working at Woolwich Arsenal during their holidays and relieve some of those working at the Arsenal. He agreed, and my son, among others, volunteered, being told to apply at the Lewisham Labour Exchange. He did so, and arranged to work there five weeks. He applied at the Labour Exchange on the Saturday, as he was supposed to start on the following Monday, for particulars as to arrangements, and was told he would not be able to start on Monday as he would have to pass a doctor, but they would let him know. No letter came, so, after waiting a few days, he called again, and was told to call on the following morning at 9.30. He did so, being then asked if he would call in the afternoon. As we live several miles from Lewisham Labour Exchange he could not do so. They then advised him to apply to our local Labour Exchange, but said they would let him know later. Up to now no letter has arrived. This unbusinesslike procedure put us to considerable trouble and expense, as my wife had put off the holidays for herself and the other children for a few days, as she wished to know how our son progressed. I had arranged for relatives to look after him, and a week of his holiday was wasted. Having nearly a month's holiday this Easter, he thought he might be able to help on the land, and again applied to the Labour Exchange, and was told to apply to some of the farms a little way out of London. So may I ask, "Do the Labour Exchanges assist any exchange of labour, or for what do they exist?"

Yours truly,

C. T. SUTTON.

62, Amott-road, East Dulwich.

WATER-TESTING APPARATUS.

TO THE EDITOR OF ENGINEERING.

SIR,—In noticing our patent salt detector on page 358 in your issue of 13th inst. you refer to the possibility of the electrolytic generation of chlorine proving a disadvantage.

As we fear this may convey a wrong impression to your readers, will you kindly permit us to point out how very remote is this possibility.

As you will see from the curves enclosed, showing results of some tests made for us by the National Physical Laboratory, the maximum current, with 220 volts across the terminals, and the electrodes only 2 cm. apart, is 0.41 ampere, with a 32 c.p. lamp in circuit, while with a 16 c.p. lamp the maximum current is only 0.25 amperes. As the 0.32 cp. lamp is only used when very minute traces of salt are to be shown, in ordinary practice a 16 c.p. lamp will be used, and the current will rarely exceed 0.15 to 0.2 amperes. You will notice that the relay operating the bell which warns of salt present acts at 0.17 amperes. Considering this, along with the electrochemical equivalent of chlorine, will show that the quantity of gas evolved is very small. Again, there is a constant flow of the water through the electrolytic cell, so that any chlorine is carried away and not allowed to accumulate.

A large firm of engineers here have used the instrument on their evaporator test bed for some nine months, and this point has never been raised, and we ourselves have had one of the instruments, with *open* electrolytic cell, working in our office for prolonged periods, and the presence of chlorine was not noticeable. We think this deals sufficiently with the point raised.

Yours faithfully,

For and on behalf of Bromell Patents Co., Ltd.,

W. CAMPBELL CROCKATT,

Director.

62, Robertson-street, Glasgow, April 14, 1917.

SOCIETY OF BRITISH GAS INDUSTRIES.—At the annual general meeting of the Society of British Gas Industries, held in London on Tuesday, April 17, Sir Robert A. Hadfield, F.R.S., D.Sc., was elected president for the ensuing year.

STRIKES IN SWEDEN.—The strike at some Swedish iron works threatens to extend to the large iron works of Sandviken and Hagfors. At the former works the men have sent in an ultimatum demanding the collective arrangements to be completed within a few days, and the local agreements to be taken in hand at the same short notice. Otherwise work will stop and the place be "blockaded." The initiative to the strike has emanated from the board of the Union of Ironworkers.

THE DESIGN OF PIN JOINTS BASED ON ULTIMATE STRENGTH.*

By Lieut. WALTER A. SCOBLE, R.N.V.R.

A FORMER paper,† written in conjunction with Professor E. G. Coker, gave the results of experimental determinations of the distributions of stress at certain pin joints within the elastic range. The results have frequently been quoted in the technical press, but unless they are considered with a full appreciation of their limitations they are likely to lead to false conclusions. Four of the principal diagrams from the early paper are reproduced here.

The first case is that of a plate tension specimen which has a hole drilled at the centre of its breadth. Fig. 1, below, shows the intensities of the stresses across the narrow section of the plate through the centre of the hole. P_t is the tension in the same direction as the pull, and P_r is a tension acting in the direction of the line on which it is plotted.

The important conclusion here is that the distribution of the principal tension across the weakened section is not uniform; it is particularly intense at the boundary of the hole, where it can be three times the value reached at the edge of the plate.

Fig. 2 applies to a similar tension specimen when the hole is fitted with a pin. The distribution of longitudinal tension is very similar to that found in the previous case, but in addition there is an appreciable radial compression between the pin and plate. The plugged hole will probably elongate at a lower load than in the former case because the material yields when the shearing stress attains a definite value.

Fig. 1. TENSION SPECIMEN WITH HOLE. PRINCIPAL STRESSES. ——— EXPERIMENTAL. ------- APPROXIMATE THEORY

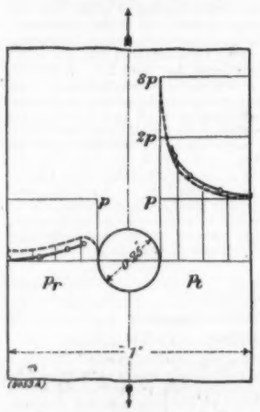


Fig. 2. TENSION MEMBER WITH RIVET IN HOLE. PRINCIPAL STRESSES.

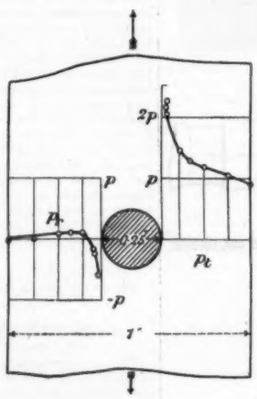


Fig. 3. LOAD APPLIED BY RIVET CASE I. PRINCIPAL STRESSES.

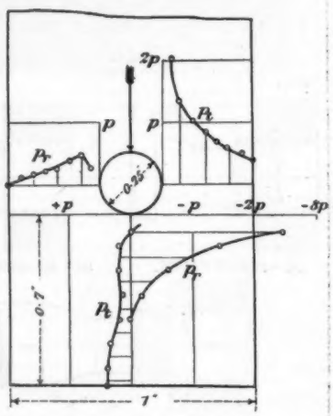


Fig. 4. LOAD APPLIED BY RIVET. CASE 2. PRINCIPAL STRESSES.

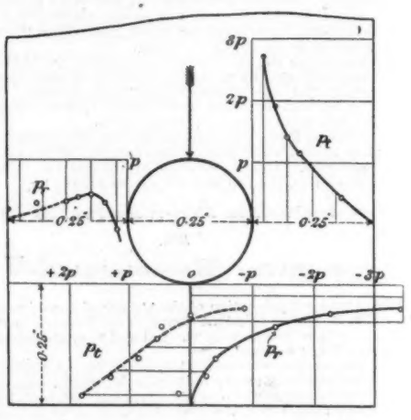
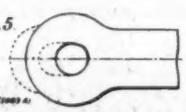


Fig. 5



The above are introductory to the practical case where the tension is applied to the member through the pin; Figs. 3 and 4, above. The specimens had square ends and were of uniform breadth. When the pin is small compared with the breadth of the plate and a considerable amount of overlap is allowed, Fig. 3, the axial tension across the narrow section varies still more than in the previous cases. But here the section directly below the hole was also investigated, and the very intense compression, P_r, where the pin bears on the plate is demonstrated. It will be noticed that this compression diminishes very rapidly as the distance from the hole increases, and disappears at about half-way from the edge of the hole to the end of the plate. The tangential stress is not particularly important. Where the diameter of the hole is greater compared with the breadth of the plate, and the amount of overlap is less, Fig. 4, the distribution of stress is even more severe. The axial tension across the narrow section is intense at the hole and zero at the edge of the plate. The radial compression between the pin and the plate is much more intense, and the tangential stress distribution on the section from pin to end of plate is somewhat like that across the depth of a beam. A pin joint affords an example of very unequal stress distribution, but, within the elastic limit of the material, the most intense stresses are localised to the region of the boundary of the hole.

A joint designed to keep the maximum stress below that at the elastic limit of the metal will have most of the material greatly understressed, and can in this sense be regarded as inefficient. If the metal yields where it is most heavily loaded, the stress distribution is altered and equalised, and the joint is then deformed but more efficient in its use of the material. The elastic strain for steel in tension is only of the order of 1/1000, therefore the deformation necessary is slight. The reduction of the ductility is negligible, because the final elongation of the metal at fracture is several hundred times that at its elastic limit. In tests where the intensities of stress vary from point to point in the specimen—bending and torsion are common examples—the failure is more gradual because the breakdown of the material is progressive. Steel yields first at the places of greatest stress, and allows the more remote metal to take a greater share of the load, and this material yields in turn as the load is increased. The region of the elastic breakdown is masked, and there is usually no true yield in the sense in which the term is applied to a simple tension test. Consideration of the points set out above—the inefficient use of the metal to the elastic limit; the relatively slight set required to equalise the stresses; the difficulty of accurate determination of the first yield, intensified in a composite specimen, without an elaborate investigation—leads to the conclusion that the maximum load carried is the best criterion for the strength of a pin joint. This opinion was supported by data collected from time to time from tests of pin joints and the like. The specimens differed too greatly to admit of a simple classification, but drawings are given against the corresponding results in Table I. In all cases a tension was applied through the pin.

Tests III, IV, and V illustrate a very interesting fact—that it is possible to design a joint in steel in which the metal on the section through the hole develops its full tensile strength at fracture. The corresponding crushing stresses should be noted; they are not more than 50 per cent. greater than the ultimate tensile strengths.

In tests I and II the metal did not carry a load corresponding to its full tensile strength. The crushing stress was approximately one and a half times the ultimate tensile strength. The hole was considerably elongated, and a piece was broken out in a similar manner to that seen in Fig. 8, page 388, specimen C. It appears that the pin crushes into the plate at the stated ratio of crushing to ultimate stress. When the hole is central through a circular end, as in specimen I, the pin crushes forward with a certain diminution of the overlap, but mainly by the elongation accompanied by the consequent lateral contraction of the metal on the sections in the region of 45 deg. to the axis of the specimen. The first stage can be imagined as shown in Fig. 5, and the specimen breaks under the pin at the narrowed section.

Tests III and IV show that the steel was fully stressed in tension at the side of the hole, although a large compression stress developed under the pin. This result was attained by leaving more metal beyond the pin, whereby the crushing did not cause sufficient narrowing on any section beyond the hole to localise the fracture. specimen V gave an equally good result, partly because the hole was set back an extra ¼ in. from the end of the plate, and partly because the crushing was relatively less intense.

The conclusions from tests I and II receive further support by the data from specimens VI and VII.

The last test of this series, No. VIII, is a somewhat surprising justification of the assumption of the equalisation of the tensile stress at fracture. The piece beyond the hole was torn out by failure of the sections shown dotted. The calculated tensile stress, assumed to be uniform across the section, agrees remarkably well with the ultimate strength of a sample cut from the same specimen. A pin joint can be designed approximately for a given ultimate strength on the lines sketched below (see Fig. 6, Table 2, page 389).

Let d be the diameter of the pin,
t be the thickness of the plate,
b be the breadth across the hole,
f_t be the ultimate tensile strength of the plate,
f_s be the ultimate shearing stress for the pin,
f_c be the ultimate crushing stress for the pin on the plate.

The tensile strength of the plate is $(b - d)\, t\, f_t$.

The shearing strength of the pin is $\frac{\pi d^2}{2} f_s$.

The crushing strength of the pin in the hole is $d\, t\, f_c$.

With complete freedom in design these strengths should be equal and the above expressions can be equated. Hence:—

$$t = \frac{\pi d f_s}{2 f_c} \quad . \quad (1)$$

$$b - d = \frac{d f_c}{f_t} \text{ or } b = d\left(1 - \frac{f_c}{f_t}\right) . \quad . \quad (2)$$

Some preliminary experiments were made to obtain values for the stresses which could be used as a check on the subsequent results. Two samples of steel were tested in tension and by shearing:—

Black round steel bar, ½-in. diameter:—

Tension: Yield stress 19.8 tons per square inch. Maximum stress 25.6 tons per square inch.

Shearing: Maximum stress 20.0 tons per square inch.

Bright rolled round steel bar, ½-in. diameter:—

Tension: Yield stress 32.7 tons per square inch. Maximum stress 35.9 tons per square inch.

Shearing: Maximum stress 24.0 tons per square inch.

The ultimate shear is 78 per cent. of the ultimate tensile stress for the black bar and 67 per cent. for the bright bar. These ratios agree well with those given by Izod* for Swedish crucible steel:—

—	Ultimate Tensile Stress.	Ultimate Shearing Stress.	100 × Ult. Shearing / Ult. Tensile
Carbon.	tons per sq. in.	tons per sq. in.	per cent.
0.12	24.9	18.5	74
0.48	42.1	28.8	68
0.71	56.3	36.6	65
0.77	61.3	38.3	62

These results show that when the shearing strength is estimated from the ultimate tensile stress it is necessary to remember that the ratio is less for the higher carbon steels.

The first set of specimens was made from black mild steel bar, 1¼ in. by ¾ in. An attempt was made to estimate the crushing stress for this steel from ball tests, using a 10-mm. ball for one minute at different loads, with the following results:—

Load, lb.	8,800	6,600	4,400	2,200
Pressure, tons per square inch calculated on area of circle of indentation	68.2	70.5	66.3	60.0

These crushing stresses were known to be too high, probably because steel near the depression is more effectively reinforced by the metal more remote than is the case in a pin joint. The joint can now be designed to suit this grade of steel ¾ in. thick, assuming that 40 tons per square inch is a better value for the crushing stress, and an ultimate shearing stress of 24 tons per square inch is allowed for the pin. Equation 1 gives $d = 0.398$ in. The ultimate tensile strength of the bar is 23.75 tons per square inch, therefore the diameter of the end, b, should be 1.069 in. A joint employed on aircraft cannot always be designed in this manner, since one dimension, in addition to the load, is often fixed by other considerations. It is necessary in different cases to carry a load on plates of different thickness. For

* Paper read at the Institution of Naval Architects, March 28, 1917.

† "The Distribution of Stress due to a Rivet in a Plate," by Professor E. G. Coker and W. A. Scoble. Spring Meetings, Inst. Naval Architects, March 14, 1913, vol. lv (i), page 207, ENGINEERING, March 28, 1913. The title was unfortunate. The case considered was a pin and not a riveted joint.

* "Behaviour of Materials of Construction under Pure Shear," by E. G. Izod, Proc. Inst. Mech. Eng., January, 1906. ENGINEERING, Dec. 22, 1905.

this reason test specimens are grouped according to the thickness as well as the material, and the load for the ⅜-in. plate was slightly reduced, by the use of a smaller pin, to represent the case in which the plate is thicker than is called for in the standard design.

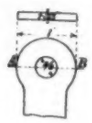
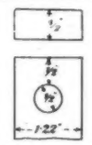
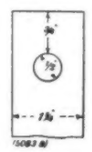
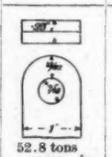
In all cases the outlines of the ends are formed by arcs of circles, joined by short straight lines when additional metal is allowed past the hole. The tests represented by letters are arranged to demonstrate the dimensions required to ensure a high tensile stress at fracture on the section A B through the hole. This is the condition which appears to be sought in the design of pin joints for structural purposes, although here the weight is of little importance. It is not clear that the joint which allows the metal to be stressed highest in tension across the hole is best for application to aircraft, and the data given below,

The joint D had its semicircular end set forward about $\frac{1}{16}$ in., with an appreciable increase of strength, and E, with a set of $\frac{1}{8}$ in., carried the full tensile stress at fracture on the critical section. The fracture took place through the centre of the hole E, and before it in B and C, therefore a joint F was made with a circular end and the hole staggered back $\frac{1}{16}$ in. This method has the advantage that no extra metal is put into the joint. Judged from the tensile stress, the strength of F is a distinct improvement on that with a central hole, although not so good as where the overlap is added without reducing the breadth at the back of the pin.

The photograph, Fig. 8, page 388, shows very clearly that the position of the fracture recedes as the overlap is increased.

Table III refers to test-pieces cut from 1¼-in. by ¼-in.

TABLE I.

Specimen.	Load at Failure.	Tensile Stress* across A B.	Ultimate Tensile Strength of Steel.	Crushing Stress under Pin.	Shear Stress on Pin.	Method of Failure.
I 	4.31 tons (on two of these plates)	25.9 tons per sq. in.	29.2 tons per sq. in.	43.2 tons per sq. in.	19.5 tons per sq. in.	Similar to C, Fig. 8, page 388.
II	Yield 3.12 tons	18.8 tons per sq. in.	17.6 tons per sq. in. yield	31.3 tons per sq. in.	14.1 tons per sq. in.	—
	Hole elongated $\frac{1}{16}$ in. 3.66 tons	22.0 tons per sq. in.	—	—	—	—
	Fracture 4.32 tons	26.0 tons per sq. in.	29.2 tons per sq. in.	43.3 tons per sq. in.	19.55 tons per sq. in.	—
III 	Yield 6.16 tons	17.1 tons per sq. in.	13.65 tons yield	24.6 tons per sq. in.	15.7 tons per sq. in.	—
	Def. yield 6.52 tons	18.1 tons per sq. in.	—	26.0 tons per sq. in.	16.6 tons per sq. in.	Not broken. Giving at side of hole.
	Ultimate 7.65 tons	21.3 tons per sq. in.	21.2 tons per sq. in.	30.6 tons per sq. in.	19.5 tons per sq. in.	—
IV	8.05 tons	43.0 tons per sq. in.	43.8 tons per sq. in.	64.5 tons per sq. in.	20.5 tons per sq. in.	Broken at side of hole.
V 	6.7 tons (hole elongated 0.01 in.)	30.4 tons per sq. in.	29.7 tons per sq. in. yield		—	—
	8.48 tons (hole elongated 0.06 in.)	38.5 tons per sq. in.	—		—	Broken at side of hole.
	9.05 tons	41.1 tons per sq. in.	40.4 tons per sq. in.	52.8 tons per sq. in.	30.0 tons per sq. in.	—
VI	7.52 tons	30.6 tons per sq. in.	47.4 tons per sq. in.	73.4 tons per sq. in.	24.9 tons per sq. in.	Broken by crushing similar to C, Fig. 8
VII	8.31 tons	36.5 tons per sq. in.	55.9 tons per sq. in.	67.5 tons per sq. in.	27.6 tons per sq. in.	Broken by crushing similar to C, Fig. 8.
VIII	9.13 tons	41.3 tons† per sq. in.	39.7 tons per sq. in.	58.8 tons per sq. in.	30.3 tons per sq. in.	Hole elongated and metal broken across narrow section at end of elongated hole.

* The tensile stress referred to is that on the section A B, through the centre of the hole perpendicular to the tension. It is calculated by dividing the tension by the sectional area of the metal.

The crushing stress is based upon the diametral area of the pin; it is estimated by dividing the load by the product of the diameter of the pin and the thickness of the plate.

† The minimum areas on the dotted lines were taken, and multiplied by cos 40 deg. to resolve the tensions across them to the line of pull.

supplemented by that from special tests, is discussed from the point of view of strength to weight ratio at a later stage.

The holes through specimens A and B, Table II, are slightly smaller than that (0.398 in.) shown above to suit the ⅜-in. bar. The shear stress on the pin attains its ultimate value before the crushing stress. The diameter of the eye, *b*, is somewhat larger than the 0.97 in. necessary to suit the pin, and in each case the pin was sheared through. The shearing stresses at fracture were 24.4 tons and 23.0 tons per square inch, whereas that in the shearing test was 24.0 tons per square inch, therefore it appears that secondary stresses, such as those due to bending, are relatively unimportant.

Test-piece C had a $\frac{7}{16}$-in. pin. Its dimensions agreed very closely with those required by the approximate theory given, the apparent tensile and crushing strengths being about equal, with the pin slightly stronger. The full stresses were not attained at fracture, this being another example of weakening by the pin crushing forward, Fig. 5, page 386.

mild steel bar. The standard design indicates a pin of 0.265-in. diameter, and the strength of the joint is fixed at 2.65 tons. Present requirements necessitate joints of greater strength being built from this plate. The diameter of the hole is increased to give greater bearing area, and the pin is drilled through to adjust its shearing strength to the specified load. The shearing stresses given in the table refer to solid pins, and indicate how much they should be drilled out in the actual joint. The $\frac{7}{16}$-in. pin carries 4.37 tons crushing load, with a stress of 40 tons per square inch, and the corresponding breadth *b* is about 1.17 in. The joints G to K had larger eyes, and were therefore stronger to resist tension than crushing. The inequality was partly balanced by the crushing strength being greater than that assumed, reaching 55 tons per square inch in one instance, but it was necessary to allow an extra 0.22-in. overlap to obtain this value with the corresponding high tensile stress.

The remaining specimens of this series were made with a ½-in. diameter pin, and a smaller diameter for the eye, to determine whether the lower compressive stress would diminish the crushing forward of the hole, and consequently for small values of *x* allow a greater tensile stress to be attained. The drastic reduction of the compression stress produced a slight improvement with a central hole, L, and when the overlap was increased ⅛ in., M, but with the more extreme examples, N and O, $x = \frac{1}{4}$ in., no improvement was shown. This result is important, because a high compression stress allows a small pin and therefore an eye of less diameter, making a lighter joint. A comparison of the corresponding specimens in Fig. 9, page 388, shows that the large pin, and the great reduction of the indenting stress, had no material effect on the elongation of the hole nor the character of the fracture.

The first specimen made from ¼-in. plate, P, was in effect a crushing test-piece, and required a stress of 82.6 tons per square inch to cause fracture. This stress value was then used to calculate the dimensions of Q, but with the central pin only about three-quarters of the estimated strength was realised. An extra ¼ in. overlap, R, brought the tensile stress much nearer the ultimate strength of the plate.

As with the ½-in. joints, a reduction of the crushing stress, by having a larger hole, allowed a central pin to carry a somewhat greater load, S, but the improvement was not maintained with the extra overlap, T. The fractures of the corresponding specimens are very similar (Fig. 10, page 388).

Table 5 refers to eyes made from $\frac{1}{16}$-in. mild steel plate. The crushing stress was determined by a special test, and specimen U was designed from this and the known tensile strength. The load carried was low, but was increased nearly 17 per cent. when the overlap was widened 0.25 in., V 1. The tensile stress was further increased by the use of a larger pin to reduce the bearing pressure, X.

In this series the thickness of the plate has been so far reduced that the eye is unstable laterally. Unless side support be given, the part under the pin is bent out of the original plane of the specimen and a tear is developed (Figs. 11 and 14, page 390). Comparison of tests V and VI shows that the side support increases the strength 26 per cent. when the crushing stress under the pin is high, and the corresponding improvement is 19½ per cent. with the lower bearing pressure represented by W and W 1. Higher loads can be carried by larger eyes as efficiently as the lower loads by smaller joints if the pressure under the pin be not increased, U and W.

The data from a few supplementary tests is recorded in the tables. A 1 is a joint somewhat similar to A, except that the pin is strengthened and the eye failed first. C 1 agrees closely with the dimensions given in the text, and gave a good result for an example with a central hole. M 1 was made to determine whether stiffening behind the hole, as well as beyond it, would effect a further improvement, but none was realised.

So far only mild steel joints have been considered, but it was thought that any metal with appreciable ductility would show results of a similar character. A brittle material does not yield to allow a redistribution of stress, and specimens were cut from a cast-iron plate (Table VI, page 389, Fig. 12, page 390) to permit an estimate of the effect of brittleness on the strength of a joint. There is no need to stagger the hole in the eye, because the pin does not crush into cast iron. The metal was somewhat defective on the fractured section of the larger specimen, but the first joint tested developed 72 per cent. of the full tension on the section through the hole. It has been shown that even cast iron yields slightly before fracture and allows a degree of equalisation of stress.*

A set of test-pieces was made from 15 gauge spring-steel plate to represent steel of higher tensile strength with less ductility. A central hole carried a low load, as before, 1, and the specimen, 2, with $x = \frac{1}{4}$ in., was 25 per cent. stronger. A larger pin, to reduce the bearing pressure, and clamped side plates, 3, effected little further improvement. When the metal was widened behind the hole as well as in front (Fig. 13, 4, page 390), the position of the fracture was slightly different and the strength was still further increased, but the difference was not very marked. 5 and 6 were eyes with double dimensions of 2, and twice the load was carried with adequate side support, but nearly one-third of the strength was lost without it.

The full tensile stress was developed on the section A B with the ⅜-in. plate, and 96 per cent. and 95 per cent. respectively with the ¼-in. and ½-in. specimens. The ½-in. plate first showed the tendency to buckle laterally under the pin, especially under a high bearing pressure, but there was only a slight indication, and the strength was apparently unaffected, except in the case of a larger specimen, R 1, made later from this plate, which showed reduced strength because the ratio of breadth to thickness had attained the value at which the plate fails in this manner. The buckling tendency became serious with the $\frac{1}{16}$-in. plate joints, and the best efficiency, estimated as above, was 78 per cent. without side support V, and became less, 67 per cent., for the larger joint of similar form, W 1, cut from the same plate. Test-piece X shows that with lateral stiffening the remarkably high efficiency of over 98 per cent. is attained even from large eyes made of thin plates. The large spring-steel joint, 6, showed nearly 90 per cent. of the full stress when supported. There appears to be rather greater difficulty in securing a high efficiency from high-tensile steel when it is thin and the load to be carried is large.

Table I shows that good results can be obtained with the higher tensile steels when not too thin. Test V

* "Brittle Materials under Combined Stress," by W. A. Scoble, Proc. Phys. Soc., London, vol. xx, 1907.

THE DESIGN OF PIN JOINTS BASED ON ULTIMATE STRENGTH.

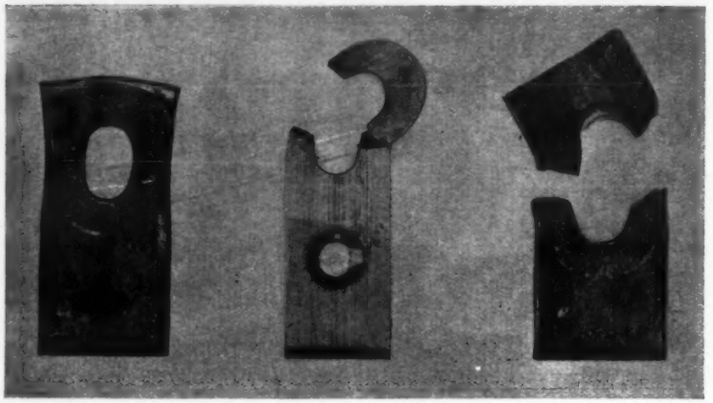


FIG. 7.

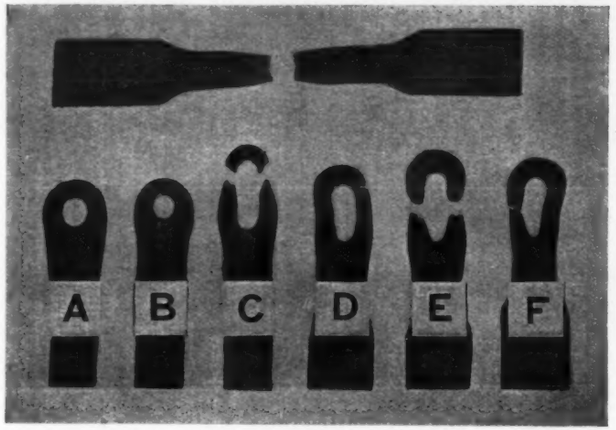


FIG. 8.

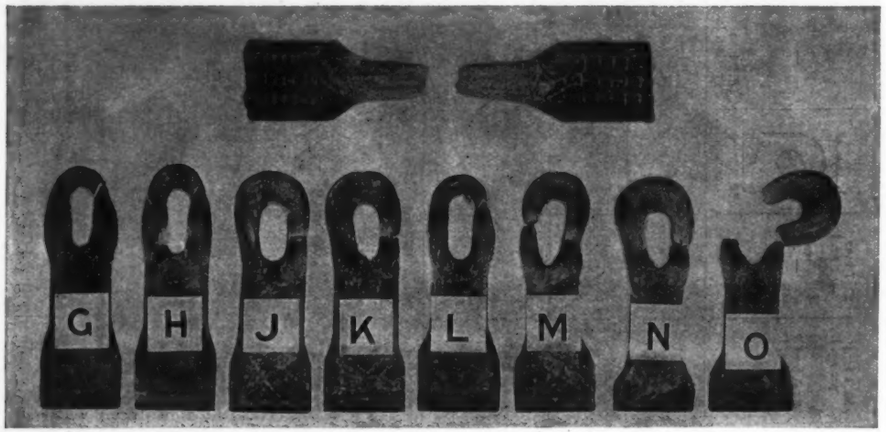


FIG. 9.

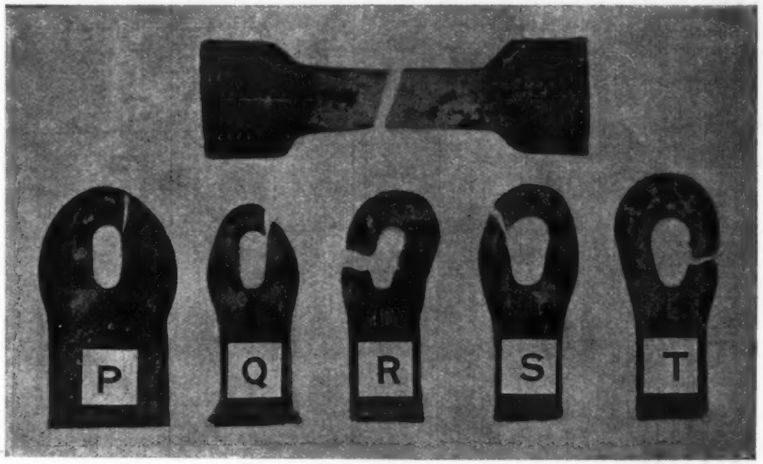


FIG. 10.

shows the full tensile stress at fracture; VIII gave a high result, but VI and VII were poor because the ends were rounded off concentrically with the hole.

The results are now considered from the point of view of weight to strength ratio. A number is calculated to represent the efficiency of a joint by dividing the load carried at fracture by the product of the volume and the ultimate tensile strength of the steel used for the eye. To compare joints made from plate of different thickness it is necessary to correct for variations in the strength of the steel. The volume taken is the thickness multiplied by an arbitrary area. The latter is obtained by taking the full circle of diameter b, the breadth of the eye, adding the extra rectangle if the thickness beyond or before the hole is increased, deducting the area of the permissible hole through the pin, and finally subtracting the area of a rectangle whose breadth is that required to carry the load, and whose length is the distance on the centre line from the assumed circular outline to the centre of the pin. The last reduction appears to be justified because the metal must extend from centre to centre to carry the load, and the area proper for the joint is that which is added to a plain bar of length equal to the distance between centres. Perhaps it is clearer to state that for the joint shown in Fig. 6, Table 2, the area taken is $\frac{\pi b^2}{4} + b x - \frac{\pi h^2}{4} - \frac{w' b}{2}$, where h is the diameter of the hole through the pin, and w' is calculated to carry the load found by the test.

The efficiency figures are given in the A sections of the tables. For the $\frac{3}{4}$-in. plate the highest efficiency is claimed by a joint with the hole staggered back in a circular end. A similar design is very good in $\frac{1}{2}$-in., best in $\frac{1}{4}$-in., and second in $\frac{1}{16}$-in. mild steel plate. But these joints are little better than those in which the hole is central through a circular end, except in the case of $\frac{1}{4}$-in. plate, of which the load carried by Q is probably low. With the $\frac{1}{16}$-in. joints staggering the hole actually decreased the efficiency. An increase of metal beyond the hole is almost justified by the additional strength if it be not excessive. A reduction of efficiency is shown when a joint departs from the standard design. In $\frac{3}{4}$-in. plate C and C 1 agree fairly well with the calculated dimensions, and the efficiency is high in each case. For A and A 1 the bearing pressure is too large without extra metal beyond the hole, and the weight is excessive for the strength. The worst results for $\frac{1}{2}$-in. steel are obtained when the overlap is too large, N and O, and with $\frac{1}{4}$-in. and $\frac{1}{16}$-in. plate when the crushing stress is too low, S, T and X, or the joint is too large, R 1 and W 1.

In general the behaviour of the spring-steel plate is similar to that given for mild steel. But here the advantage of a high bearing stress is particularly noticeable, 2 and 4, and the failure of large eyes, 6, particularly when unsupported, 5, is very pronounced. The range of tests of the character described herein might be extended indefinitely, but sufficient has been done to lead to the following conclusions to ensure light joints:—

1. Keep, if possible, to the standard design indicated

Specimens Made from 1¼ in. × ⅜ in. Black Mild Steel Bar.

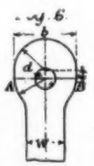
Tensile Test of Bar—Maximum Stress, 23.75 tons per square inch. Elongation, 41 per cent. on 2 in.

Table 2.

Test-piece.	*w.*	*d.*	*b.*	*x.*	Load.	Tensile Strength on A B.	Crushing Stress (pin on plate).	Shear Stress (on pin).	Remarks.
	in.	in.	in.	in.	tons.	tons per sq. in.	tons per sq. in.	tons per sq. in.	
A	0.894	⅜	1.215	0	5.40	17.1	38.3	24.4	Pin broken
B	0.894	⅜	1.125	0	5.08	18.05	36.1	23.0	Pin broken.
C	0.890	7/16	1.187	0	5.88	20.9	35.8	19.6	—
D	0.916	7/16	1.192	0.076	6.57	23.2	40.0	21.8	—
E	0.906	7/16	1.200	0.119	6.76	23.7	41.25	22.5	—
F	—	7/16	1.156	*	6.08	22.5	37.1	20.2	* Hole set back 1/16 in. in circular end.
A1	0.925	½	1.42	0	6.90	21.1	38.9	17.6	Ult. tensile strength, 23.7.
C1	0.661	½	1.03	0	4.87	19.9	34.7	22.1	—

Table 2A.

Test-piece.	*w'.*	Load / Vol. × U.T.S.	Remarks.
	in.		
A	0.606	0.76	Assumed pin solid.
B	0.570	0.85	,,
C	0.661	0.93	,,
D	0.738	0.96	,,
E	0.760	0.93	,,
F	0.683	1.01	,,
A1	0.775	0.67	Assumed solid.
C1	0.547	0.99	,,



Specimens Made from 1½ in. × ½ in. Black Mild Steel Bar.

Tensile Test of Bar—Yield Stress, 18.45 tons per square inch. Maximum Stress, 24.0 tons per square inch. Elongation, 35 per cent. on 2 in.

Table 3.

Test-piece.	*w.*	*d.*	*b.*	*x.*	Load.	Tensile Stress on A B.	Crushing Stress (pin on plate).	Shear Stress (on pin).	Remarks.
	in.	in.	in.	in.	tons.	tons per sq. in.	tons per sq. in.	tons per sq. in.	
G	1.136	7/16	1.494	0	4.86	18.75	45.4	16.1	—
H	1.185	7/16	1.490	0.12	5.48	21.2	51.2	18.2	—
J	—	7/16	1.506	0.225	5.85	22.3	54.5	19.5	—
K	1.23	7/16	1.503	0.217	5.90	22.6	55.0	19.6	—
L	—	½	1.410	0	4.50	20.2	36.7	11.5	—
L1	0.951	½	1.408	*	4.74	21.05	38.2	12.1	* Hole set back ¼ in. in circular end.
M	—	½	1.411	0.125	5.14	23.0	41.8	13.1	
N	—	½	1.488	0.25	5.32	22.0	43.4	13.5	
O	—	½	1.412	0.25	5.07	22.6	41.4	12.9	—
M1	0.942	½	1.472	0.125	5.28	22.0	42.8	13.5	Centre for back outline also staggered ¼ in.

Table 3A.

Test-piece.	*w'.*	Load / Vol. × U.T.S.	Remarks.
	in.		
G	0.826	0.75	Assumed 7/16-in. hole through pin
H	0.931	0.78	,, ,,
J	0.995	0.74	,, ,,
K	1.003	0.76	7/16-in. hole.
L	0.765	0.81	,, ,,
L1	0.797	0.823	,, ,,
M	0.874	0.84	,, ,,
N	0.904	0.66	,, ,,
O	0.863	0.70	,, ,,
M1	0.898	0.737	,, ,,

Specimens Made from ⅛-in. Mild Steel Plate.

Tension Test—Yield Stress, 21.4 tons per square inch. Maximum Stress, 30.7 tons per square inch. Elongation, 31.5 per cent. on 2 in.

Table 4.

Test-piece.	*w.*	*d.*	*b.*	*x.*	Load.	Tensile Stress on A B.	Crushing Stress (pin on plate).	Shear Stress (on pin).	Remarks.
	in.	in.	in.	in.	tons.	tons per sq. in.	tons per sq. in.	tons per sq. in.	
P	—	⅛	2.57	0	5.25	20.0	82.6	13.4	—
Q	—	⅛	1.78	0	3.86	23.8	60.8	9.8	—
Q1	1.21	⅛	1.78	*	4.21	25.8	65.7	10.7	* Hole staggered back ¼ in. in circular end.
R	1.25	⅛	1.736	0.25	4.49	29.1	71.3	11.4	
S	—		2.012	0	4.21	26.5	44.6	4.77	—
T	—		1.995	0.25	4.43	28.2	46.9	5.01	—
R1	—	⅛	2.82	0.375	5.5	29.9	57.7	6.22	Torn at hole.

Table 4A.

Test-piece.	*w'.*	Load / Vol. × U.T.S.	Remarks.
	in.		
P	1.350	0.399	Assumed—1/8-in. hole.
Q	0.991	0.662	Assumed ⅛-in. hole.
Q1	1.072	0.725	Assumed 1/8-in. hole.
R	1.153	0.675	Assumed 1/8-in. hole.
S	1.081	0.580	Assumed 1/8-in. hole.
T	1.139	0.508	Assumed 1/8-in. hole.
R1	1.413	0.279	Assumed 1/8-in. hole.

Where "*w*" is not given it was slightly greater than "*b*–*d*." See R.

Specimens Made from 1/16-in. Mild Steel Plate.

Tension Test—Yield Stress, 23.5 tons per square inch. Maximum Stress, 28.4 tons per square inch. Elongation, 22 per cent. on 2 in.

Table 5.

Test-piece.	*w.*	*d.*	*b.*	*x.*	Load.	Tensile Stress on A B.	Crushing Stress (pin on plate).	Shear Stress (on pin).	Remarks.
	in.	in.	in.	in.	tons.	tons per sq. in.	tons per sq. in.	tons per sq. in.	
U	1.088	¼	1.539	0	1.60	23.3	48.5	4.07	Supported at sides.
U1	1.000	¼	1.536	*	1.68	23.2	48.0	4.28	* Supported at sides. Hole set back ⅛ in. in circular end.
V	1.000	¼	1.548	0.25	1.56	22.6	47.4	3.98	No side support.
V1	1.023	¼	1.550	0.25	1.97	27.2	57.1	5.02	Supported at sides.
W	1.500	¼	2.282	0	2.34	24.3	49.8	2.64	,, ,,
W1	1.533	¼	2.260	0	1.96	19.4	38.2	2.22	No side support.
X	1.010	¼	1.816	0.22	1.89	28.4	40.2	2.14	Supported at sides.
Crushing test	—	¼	—	—	—	—	54.0	—	No side support.

Table 5A.

Test-piece.	*w'.*	Load / Vol. × U.T.S.	Remarks.
	in.		
U	0.840	0.765	Assumed ⅛-in. hole.
U1	0.845	0.738	,, ,,
V	0.832	0.552	,, ,,
V1	1.004	0.726	,, ,,
W	1.246	0.515	Assumed 1/8-in. hole
W1	1.006	0.383	,, ,,
X	1.065	0.601	,, ,,
Crushing test	—	—	—

Specimens Cut from the same Cast Iron Plate.

Tension Test—Maximum Stress, 10.74 tons per square inch.

Table 6.

Test-piece.	*w.*	*d.*	*b.*	*x.*	Load.	Tensile Stress on A B.	Crushing Stress (pin on plate).	Stress Shear (on pin).	Remarks.
	in.	in.	in.	in.	tons.	tons per sq. in.	tons per sq. in.	tons per sq. in.	
	1.022	¼	1.416	0	3.33	7.71	21.4	15.0	—
	1.211	¼	2.039	0	3.84	5.94	26.3	17.4	Metal slightly spongy on A B.

Specimens Cut from 1/8-in. Spring Steel Sheet.

Tension Test—Yield Stress, 31.5 tons per square inch. Maximum Stress, 47.1 tons per square inch. Elongation, 4.5 per cent. on 2 in.

Table 7.

Test-piece.	*w.*	*d.*	*b.*	*x.*	Load.	Tensile Stress. on A B.	Crushing Stress (pin on plate).	Shear Stress (on pin).	Remarks.
	in.	in.	in.	in.	tons.	tons per sq. in.	tons per sq. in.	tons per sq. in.	
1	0.738	¼	1.143	0	1.77	31.5	64.6	8.0	No side support.
2	0.775	¼	1.155	0.125	2.29	40.3	83.8	10.4	,, ,,
3	—	¼	1.26	0.125	2.29	41.4	62.8	5.85	Supported at sides.
4	0.836	¼	1.149	0.125	2.41	43.0	88.8	10.9	Centre for back outline also staggered ¼ in.
5	1.685	¼	2.28	0.25	3.17	28.6	58.3	3.6	Centre for back outline also staggered, but ¼ in. No side support.
6	1.645	¼	2.33	0.25	4.85	42.2	89.1	5.5	Similar to 5. Supported at sides.
Crushing test	—	¼	—	—	2.86	—	107.6	—	—

Table 7A.

Test-piece.	*w'.*	Load / Vol. × U.T.S.	Remarks.
	in.		
1	0.515	0.752	Assumed ⅛-in. hole.
2	0.666	0.880	,, ,,
3	0.666	0.764	Assumed ⅛-in. hole.
4	0.706	0.902	Assumed ⅛-in. hole.
5	0.930	0.251	Assumed 1/8-in. hole.
6	1.423	0.455	,, ,,
Crushing test	—	—	—

THE DESIGN OF PIN JOINTS BASED ON ULTIMATE STRENGTH.

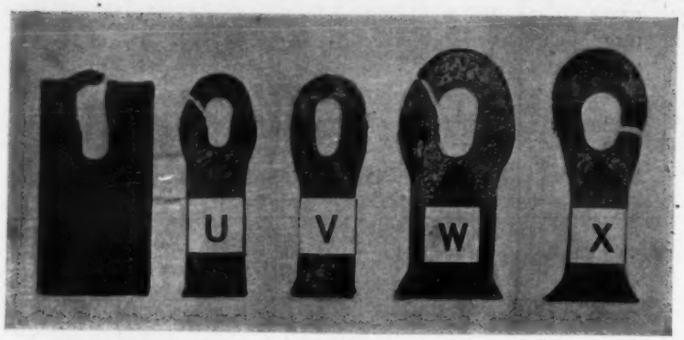


FIG. 11.

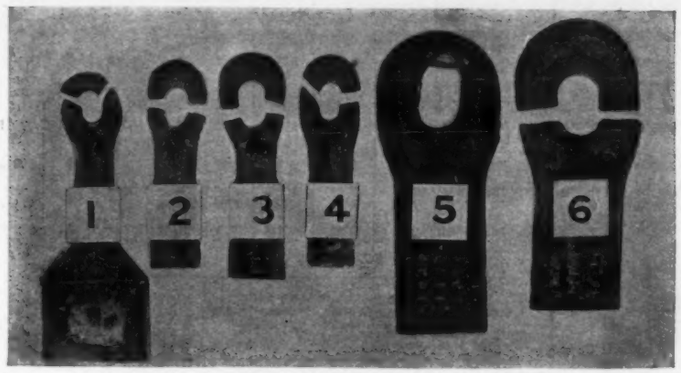


FIG. 13.

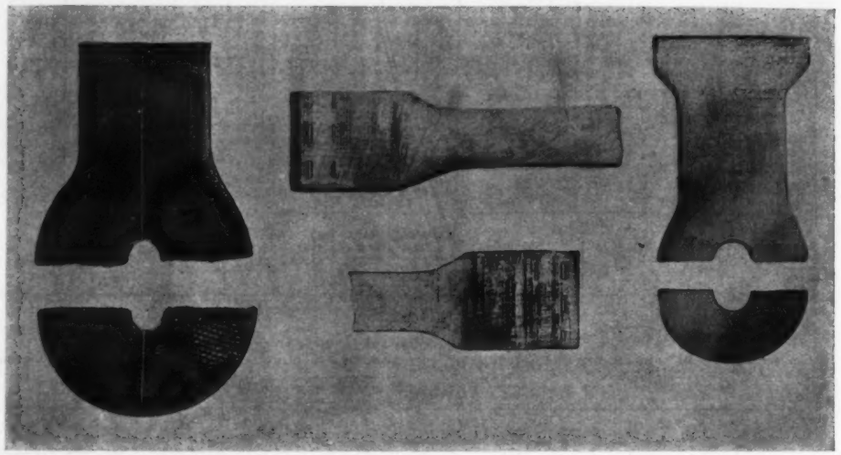


FIG. 12.

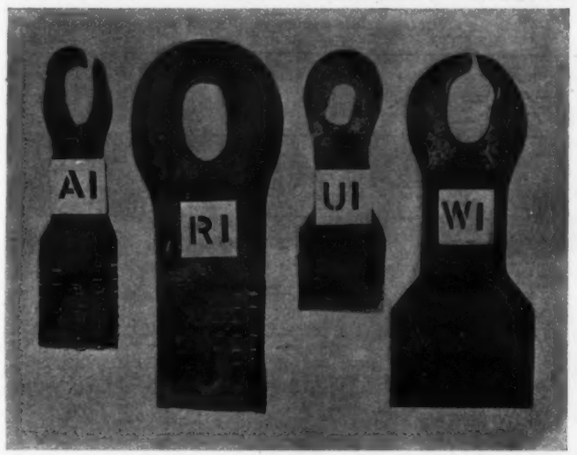


FIG. 14.

and use a solid pin. A hollow pin has d larger and leads to an eye of larger diameter and greater weight for a given load. Set the centre for the front forward about one-twentieth the breadth of the plate, $\frac{b}{20}$, when ductile steel should carry at least 95 per cent. of the full tensile stress on the narrow section.

2. If the diameter of the hole be fixed and necessitates a hollow pin, the full bearing pressure need not be developed, as it leads to a thin plate of large diameter. Halving b–d and doubling t allows the same sectional area for tension with much less weight. Moreover—

3. Buckling and tearing take place when the breadth is large compared with the thickness of the plate, unless good side support be provided. The critical ratio of b to t is under 16 for mild steel and rather higher for spring steel. $\frac{1}{4}$-in. plate was torn when $\frac{b}{t} = 22.6$, R 1, and buckled without tearing, 16, S and T; $\frac{1}{16}$-in. failed at the ratio 16, V; spring steel held at $\frac{b}{t} = 17$, and had failed when the ratio was 31.

4. The crushing stress deserves more attention than is usually given to it, especially if thin plate must be used. A higher crushing stress makes d, and hence b, less. The best ratio of bearing pressure to tensile strength found in these tests is about 1.64 for $\frac{3}{8}$-in. and $\frac{1}{4}$-in. joints, 1.71 for $\frac{1}{16}$-in. mild steel, and 1.78 for the 15 G spring steel.

5. Higher tensile steels allow a higher bearing pressure as well as a greater tensile stress, hence the gain in efficiency is greater than the proportional increase of tensile stress. But with the thin spring-steel plate only 91 per cent. of the tensile strength developed, although the full value was realised for thicker high-tensile joints.

Finally the writer desires to express his thanks to the City and Guilds Institute for the facilities for making the tests at the Finsbury Technical College, and to Mr. Dalmaine for his valuable assistance.

APPENDIX.

THE SHEARING STRENGTH OF HOLLOW PINS.

When a thin plate is used to construct a joint for a greater load than that admitted by the standard design, the hole is made larger to give sufficient bearing area, and the shearing stress on a solid pin is less than it should carry. The joint is made lighter by drilling through the pin. It was thought that a hollow pin with a thin wall might collapse under the bearing pressure and not develop the full shearing strength of the steel. Such pins were tested and the results are shown in the table annexed. Pins made of either steel carry 90 per cent. of the full shearing strength with $\frac{d}{D} = 0.75$. With larger holes the wall becomes very thin and the strength shows a considerable reduction. The centre plate was $\frac{1}{4}$ in. and the side plates $\frac{1}{8}$ in. thick. Thinner plates would have given higher bearing pressures and might cause a further reduction of strength.

Strength of Hollow Pins.

Outside Diameter, inches, D.	Inside Diameter, inches, d.	$\frac{d}{D}$	Load in Double Shear, lb.	Stress, tons per sq. in.
		Bright Rolled Steel.		
0.5000	0	0	23,000	26.2
0.4993	0.2530	0.506	17,060	26.2
0.4990	0.3220	0.645	12,250	23.9
0.5000	0.3810	0.762	8,700	23.6
0.4990	0.4465	0.895	3,300	18.8
		Black Mild Steel.		
0.4993	0	0	14,720	16.8
0.4995	0.2530	0.507	10,490	16.1
0.4998	0.3210	0.642	8,130	15.75
0.4990	0.3820	0.766	5,530	15.2
0.4990	0.4520	0.906	2,180	13.75